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[THIRD SERIES.]

ART. XLVIII.—*On the Proper Motion of the Trifid Nebula*: M. 20 = H. v; 10, 11, 12 = h. 1991, 3718 = G. C. 4355.

[R. A. = $17^h\ 53^m\ 51^s{\cdot}8$, N. P. D. = 113° 1′ 39″·9; 1860·0];

by EDWARD S. HOLDEN.

[Read in Abstract to the American Association for the Advancement of Science.]

IN a paper in this Journal for May, 1876, on the supposed changes in the Nebula M. 17, I said (p. 360): "A remarkable instance of proper motion of this latter kind is that of the *Trifid Nebula* G. C. 4355, which has moved since 1833 so that the remarkable triple-star which was then quite clear from the nebulosity in a dark space formed by the junction of the three dark channels, is now by the evidence of Lassell (1863) Winlock and Trouvelot (1874) and myself (1875) well involved, the motion being confirmed by Herschel's drawing at the Cape of Good Hope (1837) and Mason's of about the same date."

It seems proper to collect the evidence now existing on this point in order to show the desirability of the study of this nebula, and because, in case the indications which we there find of a decided proper motion should be confirmed, such results would be of importance.

Following I give in chronological order such extracts from published and unpublished observations of this nebula as bear on the points now under consideration, italicizing such portions as deserve particular attention.

OBSERVATIONS OF THE NEBULA.

This nebula was discovered by MESSIER June 5, 1764, but he gives no details concerning it.—*Hist. de l'Acad. R. des Sciences*, 1771, p. 443.

Observations of Sir WILLIAM HERSCHEL.

1784. July 12: "Three nebulæ faintly joined form a triangle. *In the middle is a double star.* Very faint and of great extent." —*Phil. Trans.*, 1786, p. 494.

1786. May 26: "A double star with extensive nebulosity of different intensity. *About the double star is a black opening*, resembling the nebula of *Orion* in miniature."—*Phil. Trans.*, 1789, p. 247.

1811. . . . . : "Three nebulæ seem to join faintly together forming a kind of triangle; the middle of which is less nebulous, or perhaps free from nebulosity; *in the middle of the triangle is a double star*, etc."—*Phil. Trans.*, 1811, p. 289.

236 Sweep. July 12, 1784: "Between 3 nebulæ (10, 11, 12, V class) is a double star."—*Mem. R. A. S.*, i, p. 167.

566 Sweep. May 26, 1786: "A double star within nebula IV, 41."—*Mem. R. A. S.*, i, p. 170.

Observations of Sir JOHN HERSCHEL.

1826 . . . . . : "In the nebula R. A. $17^h\ 52^m$, N. P. D. 113° 1′ in *Sagittarius* * * * * the idea of an absorption by the double star in its middle is very forcibly suggested. This nebula is broken into three parts, and the three lines of division meet in *a vacancy, in the midst of which is situated the double star. This curious object has perhaps a proper motion.*"—*Mem. R. A. S.*, ii, p. 490.

Fig. 1. HERSCHEL, 1833.

1827 . . . . : "*A double star placed exactly in the central vacuity of a large irregular nebula*, which appears to have broken up into three portions by three rifts or cracks, extending from its center to its circumference, and *whose directions meet at the double star.*" —*Mem. R. A. S.*, iii, p. 63.

1833 . . . . : "*The double star* Sh. 379 *in the center of the trifid nebula*" . . . . [sweep 275].

"A careful drawing taken, but the nebula is not clear from twilight and clouds. (N. B. This drawing is unfortunately lost, and that engraved in fig. 80 is constructed from much less elaborate sketches, aided by memory.)" . . . . [Sweep 32.]

"Very large; trifid, three nebulæ with *a vacuity* in the midst, *in which is* centrally *situated the double star* Sh. 379."—*Phil. Trans.*, 1833, p. 460.

If we had nothing but the preceding evidence with regard to this nebula we should be justified in laying down the following proposition with regard to the situation of the triple star relative to the three nebulosities.

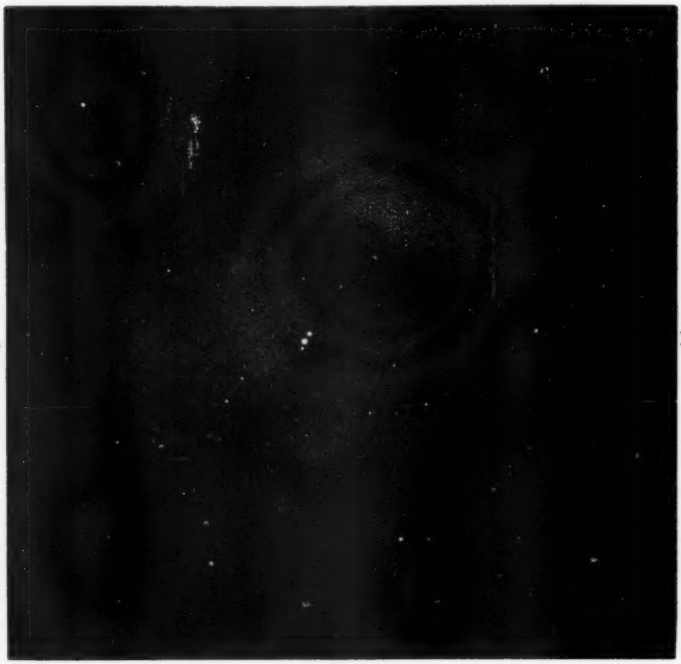

Fig 2. Mason and Smith, 1839.

3. *From* 1784, *July* 12, *to* 1833, *this triple star was centrally situated between the three nebulosities.* The evidence is based upon two observations of Sir William Herschel and four observations of Sir John, and in the *Phil. Trans.* for 1811 Sir William again repeats his former statements.

Observations of MASON and SMITH.

1839. August 1: "*The double star is certainly not as figured in Phil. Trans.*, 1833, *but rather adhering to the* [*eastern*] *of the three divisions.*"

1839. August 9 . . . : "*The triple star is certainly not central, but involved* * * *."—*Trans. Amer. Phil. Soc'y*, vol. vii, pp. 175–176.

Fig. 3. HERSCHEL, 1834–8.

Observations of Sir JOHN HERSCHEL *at the Cape of Good Hope.*

1835. August . . . : "I have been rather unfortunate in my figures of this nebula. That given in my Northern Catalogue (our figure 1) is not to be taken as more than an attempt, and that a most rude and imperfect one, to show *the situation of the fine triple star in its center with respect to the nearer portions of the three principal surrounding nebulous masses.*

Herschel then speaks of the drawing of Mason (our figure 2) as follows:

"On comparing our figures they will be found to agree in every essential particular, allowing for the difference of light between reflectors of 12 and 18 inches aperture, with one rather remarkable exception, viz: in the form of the southern mass of the trifid nebula and the character of the three paths or avenues which lead up to the triple star. Mason represents these avenues as free from any abrupt change of direction, the northern and preceding of them branching out with and easy and graceful bifurcation from

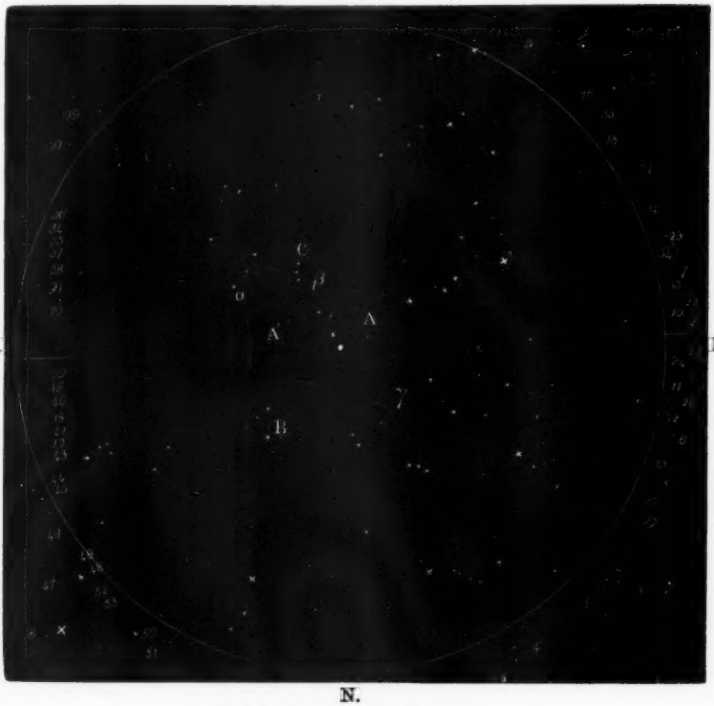

Fig. 4. Index-Map. (LASSELL.)

the southern; whereas my figure, whose correctness in this respect I cannot doubt, gives the preceding avenue a remarkably sudden and uncouth flexure, like a gnarled branch of an oak, just at its divergence from the other two."*—*Astron. Obser. Cape of Good Hope*, p. 10.

* In Mason's Memoir, Art. 46, p. 199, this appearance is recorded among the things "slightly suspected." His figure represents only "things certain," and probably Sir John Herschel referred only to the drawings in his comparisons.

The observations of Secchi* (1852–5) and of D'Arrest† (1866, June 2) throw no light on the position of the triple star relative to the nebula.

Later observations of the nebula are those of Lassell, Langley, Trouvelot and myself. (It has also been observed at Melbourne, but the Melbourne results are yet unpublished.)

Lassell's two figures are of high importance, having been made under the most favorable conditions at Malta with his 4-foot reflector, an instrument well suited to the purpose. They are published in the Memoirs of the Royal Astronomical Society, volumes xxxiii and xxxvi.

No verbal description of the nebula is given by Lassell, but the drawings are complete in themselves, and the evidence to be derived from them will be considered hereafter. The following micrometric observations were made by Lassell. In order to present the nomenclature of the stars the Index-Map (Lassell's) is given.

Table I.—Lassell's Star-Positions.‡

[The positions are referred to Star 1.]

Star 1 and Star —.	Observed.		Computed.	
	p.	*s.*	$\Delta\alpha$.	$\Delta\delta$.
3	25° 46′	270″·15	+117″·44	+243″·30
4	333 4	243·20	−110·16	+216·82
5	54 31	215·37	+175·38	+125·02
7	116 49	181·21	+161·72	− 81·75
8	311 24	391·68	−293·81	+259·03
10	121 30	90·39	+ 77·07	− 47·23
14	3 43	177·17	+ 11·49	+176·80
15	167 52	249·25	+ 52·39	−243·69
21	235 40	129·17	−106·67	− 72·85

Observations at Harvard College Observatory in 1866 *by* Prof. Langley.

Through the courtesy of Prof. E. C. Pickering, Director of the Observatory of Harvard College, I have been enabled to extract from the observing books portions of observations made by Prof. S. P. Langley in 1866 with the 15-inch refractor of that institution. These are given immediately following, and in the proper place I have also given results derived from manuscript sketches by Prof. Langley. The measures of star coördinates are complete so far as they extend. I am informed by Prof. Langley that the sketches were, however, not regarded as completed, and therefore I shall only give those deductions from them which appear to have been regarded as certain at the time of observation. I desire especially to convey my thanks to Professors Langley and Pickering, who have allowed me to use these valuable materials.

* Mem. dell' Oss. Coll. Romano, 1852–55, p. 89.

† Abhand. d. k. Säch. Gesell. d. Wissenschaften, vol. v, p. 343.

‡ Memoirs Royal Astronomical Society, vol. xxxvi, p. 49.

Observations at the Harvard College Observatory.

1866. July 31.

Prof. Langley discovered the 4th star of Sh. 379 (D), which he estimated 13 mag., and which he described as "blue." It was independently seen by Prof. Winlock. Measures of coördinates made.

1866. August 2.

[The following remarks are copied *verbatim* from the original observing books, except that I have replaced the letters which are assigned to the stars by Prof. Langley, by Lassell's numbers, for the sake of uniformity. The explanations in square brackets are my own.]

"The nebula is brightest at 1. 6 and 11 are, if anything, outside of its confines. The prolongation [*north* of] 5 is very faint. It diminishes [in brightness] very slightly and uniformly toward 10 and 7? 1 is involved in faint nebulosity, which bridges the dark channel. The region about 1, 18, 12 is somewhat brighter than that in the triangle 7, 10, 11. 12 and 13 are a little within the nebulosity. The region [C] devoid of stars is perhaps the brightest part of the nebula, the dark channel [*south* of] 1 appearing relatively well defined. The whole heavens in the vicinity are (dubiously) nebulous."

1866. August 11.

Measures of coördinates of stars [omitted]. "Observed just *south* of 1, 10, 7, a faint, straight, narrow channel nearly filled up with nebulous matter. Was less confident to-night that the nebula surrounded the quadruple star, which seemed to be in the channel with blackness on each side, less in the *preceding* than in the *following* side."

1866. August 13.

Fifth component (E) of Sh. 379 discovered by Prof. Langley.

1866. September 10.

The entire region *south* of 1 [C] is judged, as before, to be the brightest part of the nebula, or nearly so. Cannot feel sure that there is *any* nebulosity about 1. The channel [*south* of] 1, 10, 7, is rather suspected than seen.

The drawing of M. Trouvelot was made with the aid of the Harvard College refractor (of 15 inches aperture) in 1874, and is published in the Annals of the Harvard College Observatory, vol. viii, plate 32. This plate is not here reproduced, as it has only recently been published, and is in the hands of astronomers. The evidence to be derived from it will be considered in its proper place. The following observations made by me with the 26-inch refractor of the U. S. Naval Observatory complete the materials at our disposal.

*Washington Observations in detail.**

I give the Washington observations almost literally from the

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observing books, in order that they may serve for future comparisons. Not infrequently a verbal statement can be made more definite and satisfactory than the presentation of the same evidence in a drawing.

Washington Observations.

1874. August 12. Observers, S. W. Burnham and E. S. Holden: the subsequent observations are by the latter observer.

Sketch of stars made. 37 and 38 faint. Within 35″ of Sh. 379 are 4 stars, I, II (=Lassell's 20), III and IV. [These have been subsequently measured, see *Wash. Ast. Obs.* for 1874–5–7; of these I and IV were discovered by Prof. Langley at Harvard College Observatory.]

34 equal in brightness to 36. [The principal work of this night was the making of the star-chart.]

6 is certainly inside the nebulosity, but is close to its *preceding* edge. 11 is inside the nebulosity by $\frac{1}{8}$ of the distance from 6 to 11, but the nebulosity is faint there; 12 and 13 both inside; 12 is nearer to the *following* edge of the nebula than 13. 52 is inside the nebulosity? ? Clouds prevent further work.

1875. August 5.

6 is on the edge of A. 11 is on the edge of a brighter streak, but follows the *extreme* edge by about $\frac{1}{8}$ the distance 6–11. From 11 to the point near the triple star [this refers to the point of the edge of the nebula A *north* of 1–2–19 and about the prolongation of the line 1–2; August, 1877] the edge is *faint* and tremulous. 12–13–52 all inside the nebulosity. In the line 13–52 the distance to the *following* edge (which is not always sharp) is about equal to the distance from 13 to 52. [This distance is to be measured from 52 toward the *following* side. 1877.]

A figure was made, from which the following notes are derived. The nebula is condensed around star 4. If a line be drawn joining 12 and 40, and if through 18 a line be drawn parallel to the former, this last line cuts the *preceding* edge of B at a distance from 18 equal to the distance 18–40. [This is quite different from Lassell's second figure, where the line described cuts the edge at a distance from 18 equal to about $\frac{1}{3}$ or $\frac{1}{2}$ of the distance 18–40.]

[The nebulosity near 44, 45, 41, 43 agrees with Lassell 1864 in the arrangement of the two degrees of brightness of the nebula.]

41, and 36, 37, 38 are all involved. 41 is involved by about the distance from 36 to 37?

20 is about the middle of the dark channel β [see index-map]. The angle of position of this channel β is 160° (1 measure).

β extends $\frac{2}{3}$ of the distance from 20 to 9. [16?]

32 is immersed in nebulosity. The line 20–9 [16?] is nearly the axis of β.

[A second sketch of the bounding lines of the nebula made, which agrees more nearly with Lassell 1864 than the first one of this night, in the position of the nebulosity relative to the stars 18 and 40.]

The triple star Sh. 379 is really sextuple.

1877. July 2.

The following stars were identified and placed on the chart: 1, 2, 3, 4, 5, 6, 7, —, 9, 10, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, —, —, 44, 45, —, —, 48, 49, 50, 51, 52, —, 54, 55; leaving stars 8, 42, 43, 46, 47, 53 to be subsequently charted.

1877. July 6.

Measures of p, $\Delta\delta$, etc. See Table II. *Notes.*—48 has a little less $\Delta\delta$ than 18. 44 has a little greater $\Delta\delta$ than 18. The p of 1 and 12, 19°·2, is nearly that of 1 and 19. If anything the p of 1 and 19 is greater than that of 1 and 12.

1877. July 12.

Measures of p, $\Delta\alpha$, etc. See Table II. *Notes.*—The line 12–13 passes *west* of 1, and the nebulosity near 1 is still *west* of this line. Star 3 is *east* of the line 12–13 by about 1″ (est.). The line 1–18 bisects A (roughly speaking). 7 *precedes* 5 a little.

Along the line 14–20 there is nebulosity to the edge of γ, then darkness to the edge of A, then nebulosity to the edge of A again, then darkness in β. That is, the *preceding* edge of A is cut off by the line 14–20.

The nebulosity of A just *following* the line 14-20 is fainter for 3″-6″ (est.); but beyond this limit it is uniformly bright up to 1, 2, 19.

1877. July 13.

The line 14–20 is situated in regard to the nebulosity as in figure [omitted]; that is, the line 14–20 really passes through the nebula near 1, 2, 19, but through a fainter part. It is, however, *about* tangent to nebulosity of the same brightness as that near 1–2 on the following side. Eye-piece 175. The figure omitted shows following 1, 2, 19 a fainter band or dark channel, so that these three stars seem to be symmetrically situated in a brighter part of the nebula with fainter nebulosity again surrounding that, as if the nebulosity had condensed about these stars since Mason's drawing.

1877. July 16.

Measures of p and $\Delta\alpha$. See Table II. I suspect D to be variable. 11 very faint.

1877. July 25.

Measures of $\Delta\alpha$, $\Delta\delta$. See Table II. D and E seen. D is far brighter than any other of the small components of Sh. 379, of which only D and E are visible to-night. E is quite faint. E$<$20.

1877. July 26.

Moonlight. Placing the micrometer wire through 12–13 the wire runs *west* of 1, 2, 19, but is involved in fainter nebulosity near them. Half way from this wire to star 1 the nebulosity becomes bright, and so continues up to and beyond [*following*] 1.

With eye-pieces 400 and 600 A, the three stars 1, 2, 19 appear to be about symmetrically surrounded by an oval mass of nebulosity, separated from the rest of A by a fainter band following 1, 2, 19.

Line 14–20 is involved in A near 2, but only in fainter nebulosity.

Line 1–10 is involved *west* of 1 in brighter nebulosity by some seconds.

1877. July 30.

V. The line 3–35 is almost exactly parallel to the line 12–13, and intersects the nebulosity A near 1, 2, 19. This line is tangent very exactly to the *preceding* edge of the brighter nebula about these three stars.

Angle of position of β, passing through 20 and 16 (not 9), 162°·7 (1).

New dark channel between 1 and 10, as in sketch. It extends no further *east* than 10, and 10 and 11 are on or near its *following* borders. Its *preceding* border is 20″–30″ *following* 1, 2, 19. The seeing is poor, and this point should be reëxamined.

(A) The brightest part of the nebula is about the triple star. It is an oval mass nearly symmetrically disposed about the triple star. The triple star is, if anything, toward its *western* side.

(B) The next brightest nebulosity is near 36, but this is not much brighter than (C) or the brightest parts of (B) near 18.

(D) Stars 12–13 are both inside the nebulosity. [See Observations of 1875, Aug. 4; 1877, July 12, July 26.]

(E) Star 11 is on the very edge of a brighter portion, but *follows* the *extreme* edge by $\frac{1}{3}$ the distance 6 to 11. [See Observations of 1875, Aug. 4.)

(F) Star 26 is within the brighter nebulosity, the boundary line of which runs (see sketch) [omitted] between 5 and 26, but much nearer 26 than 5; perhaps $\frac{1}{4}$ of the distance 26 to 5.

(G) [Star 6 is certainly inside the nebulosity, about half way from the *preceding* edge of the fainter nebulosity to the *preceding* edge of the brighter.] See Observations of 1875, Aug. 4, Aug 5.

(H) Stars 5, 27 and 28 are on the *preceding* edge of the fainter parts of A. [But *preceding* 5, 7, 28 it is not totally black.]

(J) The triangle 40, 44, 21 has no nebulosity which is at all bright within it except A′.

(K) 21 is involved in C a few seconds, but it is close to its *north* edge. 35 is well involved. 36, 37, 38 are correct on the map.

1877. July 31.

$\Delta\delta$, 21 and 1, −65″·73 (3), −0″·09 refraction, $\Delta\delta = -65''\cdot82$. This is about the mean of the $\Delta\delta$'s of 38 and 37. Sketch of stars, etc., near 5, 17, 28.

The atmosphere on this night was more favorable than previously during the year, and the principal work was devoted to the examination of the apparent differences between Lassell's and Trouvelot's figures.

It appears that in an eye-piece having a small field (8′–9′), when 5, etc. is in the northern part of the field, and the eye endeavors to trace the *following* borders of the channel γ, that it is easy to gain the impression that 5 is on or near the *preceding* edge of A, and that *preceding* 5, 27, 28 the dark channel γ was prolonged toward the *north*. In this way the appearances of Herschel's, Mason's and Trouvelot's figures are reproduced.

Placing 5 in the center of the field, and thus avoiding the disturbing effect of the well marked border of the channel γ near

6 and 11, the appearances of Lassell's figure are most nearly represented. As before described, the nebulosity between 5 and 26 is mostly faint, but near 26 it becomes brighter, so that 26 is involved now more deeply in the brighter parts of (A) than is given by Lassell, and not so much as given by Trouvelot.

The nebulosity immediately about 4, 27, 28 is faint. The dark channel γ ceases to have well marked edges south of 5. The faint nebulosity about 5, however, does not seem to be connected (as in Lassell's figure) with (B).

August 3, 1877.

Night very clear. 1 and 14 ($\Delta\delta$) $= -211''{\cdot}37$ (2), $-0''{\cdot}30$ refraction, $\Delta\delta = -211''{\cdot}67$ (2). Lassell gives $-243''{\cdot}7$, and I presume there is an error in the numbering here.

Order of brightness of the principal stars.

1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 13, 14, 18, 20, 26, 21, 25. 39 and 24 are quite faint. Lassell's order of brightness is therefore maintained. Nebulosity was traced *north following* Sh. 379 a considerable way, about half a degree to a nebulous star 8^m, but I was hindered in this by clouds which finally covered the whole sky. The same hindrance occurred in the same way on the clear night of July 31. The connection of this nebula with neighboring ones deserves examination, as it is widely extended, but no opportunity offered during 1877 for this work.

With regard to the triple star: It was first seen double by Wm. Herschel, and triple by South and Herschel. Lassell with his four-foot reflector saw only three stars. Two stars, D and E, are to be seen on any clear night, D being about equal to star 20 in brightness and E tolerably faint. [I find among my notes several times a suspicion recorded that D is variable.] D and E were first seen by Prof. Langley with the Harvard College 15-inch refractor. They are both given by Trouvelot in his figure, together with a star *s.f.* 1, and very close to it. I have not seen this star in 1877. A = Lassell 1; B = 2; C = 3; F = 39.

The approximate positions of the various components are:

		p.		*s.*	
A and B	:	211°	:	$10''{\cdot}8$	Sh. 379
A and C	:	22	:	$6{\cdot}5$	Sh. 379
B and D	:	283	:	$2{\cdot}5$	
A and F	:	107	:	$19{\cdot}5$	
B and E	:	193	:	$5{\cdot}8$	

This nomenclature includes Trouvelot's star s. f. 1. I have several times suspected the existence of a small star *n. p.* A. $p = 310° \pm$; $s = 6''$. For measures of the above stars, see the Washington Astronomical Observations and Burnham's Catalogue of Double Stars.

Prof. Eastman, U. S. N., has kindly undertaken to observe the triple star Sh. 379 on the Transit-Circle, in order to fix its position b solutely.

The Washington observations of star positions are given in the table following. It will be noticed that in the column "Holden–Mason" the errors are usually within the limits set by Mason himself.

Table II.—Summary of Washington Observations of Stars in M. 20.

Date. 1877.	*p.* from 1.	Obs'd Δa from 1.	Diff. Refr.	Δa.	No. Obs.	Obs'd $\Delta\delta$ from 1.	Diff. Refr.	$\Delta\delta$.	No. Obs.	Star No.	Holden—Mason. Δa.	Holden—Mason. $\Delta\delta$.	Holden—Lassell. Δa.	Holden—Lassell. $\Delta\delta$.
		s	s	s		+113s·71	0s·15	+113s·9	2		s	s	s	s
July 6	55·9°(3)													
12	--	+166·56	+0·02	+166·6	3	--	--							
13	56·1 (2)	--				--	--			5	−10·0	+1·0	−8·1	−11·2
16	--	+167·25	+0·01	+167·3	2	--	--							
25	--	+167·92	+0·01	+167·9	1	+113·53	0·14	+113·7	2					
Means	56·0			+167.27				+113·80						
July 6	56·6 (3)	--	--			+67·35	0·08	+67·4	2					
12	--	+101·22	+0·01	+101·2	2	--	--			6	+5·4	+7·1	--	--
13	56·8 (2)	--	--			+66·86	0·09	+67·0	2					
16	--	+101·41	+0·01	+101·4	2	--	--							
Means	56·7			+101·30				+67·20						
July 6	65·3 (3)	--	--			+39·20	0·05	+39·3	2					
12	--	+83·78	+0·01	+83·8	3	--	--			11	+4·0	+0·1	--	--
13	65·5 (2)	--	--			+38·53	0·05	+38·6	2					
16	--	+83·66	0·00	+83·7	2	--	--							
Means	65·4			+83·75				+38·95						
July 6	23·6 (3)	--	--			+119·67	0·15	+119·8	2					
12	--	+51·58	+0·02	+51·6	2	--	--							
13	23·3 (2)	--	--			--	--			12	+1·8	+9·7	--	--
16	--	+51·66	+0·01	+51·7	3	--	--							
25	--	+51·52	+0·02	+51·5	1	+119·13	0·15	+119·3	4					
Means	23·5			+51·60				+119·55						

Table II—continued.

Date. 1877.	p. from 1.	Obs'd $\Delta\alpha$ from 1.	Diff. Refr.	$\Delta\alpha$.	No. Obs.	Obs'd $\Delta\delta$ from 1.	Diff. Refr.	$\Delta\delta$.	No. Obs.	Star No.	Holden—Mason. $\Delta\alpha$.	Holden—Mason. $\Delta\delta$.	Holden—Lassell. $\Delta\alpha$.	Holden—Lassell. $\Delta\delta$.
		′	′	′		″	″	″			′	′	′	′
July 6	19°·2(3)					+75″·41	0″·09	+75″·5	2					
12	--	+26·00	+0·01	+26·0	2	--	--							
13	19·5 (2)	--	--			+75·18	0·10	+76·3	2	12	+0·2	+4·0	--	--
25	--	+26·00	+0·01	+26·0	2	--	--							
Means	19·4			+26·00				+75·90						
July 12	--	+11·84	+0·03	+11·9	2	--	--			14	--	--	+0·9	−2·4
13	4·1 (2)	--	--			--	--							
25	--	+12·86	+0·06	+12·9	3	+174·19	0·23	+174·4	2					
Means	4·1			+12·40				+174·40						
July 6	213·0 (3)	--	--			−33·1::	0·04	−33·1::	3	20	--	--	--	--
12	--	−22·9	−0·00	−22·9	3	--	--							
13	--	--	--			−34·46	0·04	−34·5	2					
25	--	--	--			−33·43	0·04	−33·5	3					
Means	213·0			−22·90				−33·7						
July 6	--	--	--			+88·34	0·11	+88·45	2	18	+1·0	+7·6	--	--
12	--	−69·18	+0·01	−69·2	1	--	--							
13	321·9 (2)													
Means	321·9			−69·20				+88·45						
July 6	334·4 (3)	--	--			+212·39	0·25	+212·64		4	--	−3·9	--	−2·2

Besides the above measures, which are all referred to Star 1, the following angles of position have been measured:

July 12: Stars 12 and 13, $p = 30°{\cdot}5$ (3) } 1875, Aug. 5: Angle of position of β : 160°·0 (1)
July 13: Stars 14 and 20, $p = 189°{\cdot}7$ (1) } 1877, July 30: Angle of position of β : 162°·7 (1)

It should be noted that the measures on which the above positions depend have all been made under very unfavorable circumstances.

Table III.—Star Positions according to Herschel, Mason, Lassell, Langley and Holden.

Star's Number.			Magnitude.		Herschel.		Mason.†		Lassell.		Langley.		Holden.	
Lass.	Hersc.	Mason.	Hersc.	Mason.	$\Delta\alpha$.	$\Delta\delta$.*	$\Delta\alpha$.	$\Delta\delta$.	$\Delta\alpha$.	$\Delta\delta$.	$\Delta\alpha$.	$\Delta\delta$.	$\Delta\alpha$.	$\Delta\delta$.
8									−293″·8	+259″·0				
4	1	2	12	11·12	−120″·0	+211″·3	−111″·8	+216″·5	−110·2	+216·8	−103″·1	+210″·8	--	+212″·6
21									−106·7	−72·9			--	−65·8
--	2		15		−103·5	+93·6								
40?		3		16			−98·7	+28·9						
21??		4		16			+83·7	−39·1						
18		5		15			−70·2	+80 9					−69″·2	+88·5
35	5		15		−61·5	−72·1								
36														
37	?	6		16			−41·7	−63·1						
38														
20													−22·9	−33·7
14	7?		15		−4·5	+199·5			+11·5	+176·8	+11·0	+176·6	+12·4	+174·4
12	10	11	13	15	+27·0	+86·5	+25·8	+71·9			+26·1	+74·6	+26·0	+75·9
15?		12		15			+33·3	−187·1						
16?														
13	11	13	13	15	+48·5	−128·6	+49·8	+109·9			+50·5	+118·2	+51·6	+119·6
15‡									+52·4	−243·7				−211·7
10		16		14			+66·3	−34·1	+77·1	−47·2	+68·5	−37·8		
11		17		14·15			+79·8	+38·9			+84·1	+37·9	+83·8	+39·0
11?	13		13		+99·0	+27·6								
6	15	19	11	12·13	+106·5	+69·7	+95·9	+60·0			+100·9	+68·2	+101·3	+67·2
22?	17		12		+114·0	−67·3								
33?														
3	18	21	11	11·12	+114·0	+240·4	+118·7	+239·7	+117·3	+243·3	+119·1	+237·0		
7		24		12·13			+172·1	−70·4	+161.7	−81·8	+159·9	−76·1		
5	24	25	11	12	+178·5	+108·0	+177·3	+112·8	+175·4	+125·0	+169·2	+114·3	+167·3	+113·8

* The sign of $\Delta\delta$ as given by Herschel in C. G. H. Obs. has here been changed.

‡ There is some error in the numbering of 15.

† Mason estimates the mean errors of his star positions as $\pm 0^s\cdot399$ and $\pm 6''\cdot37$.—*Op. cit.*, p. 192.

Position of the mass A relative to the triple star.

It will be convenient to examine the various drawings with regard to special points, and to lay down a series of propositions (so to say) from each figure which can afterwards be compared among themselves. The situation of the triple star with respect to the adjacent nebulosity being of importance, I give in what immediately follows five statements derived from each drawing, which go to show the position of the nebulosity *A* near the triple star at the epoch of the drawing.

The statements derived from each drawing are here placed together, in order to facilitate the comparison between the original engravings and the propositions I have derived from them. In the actual examination of the drawings, each one was studied separately, and all the evidence to be derived from it recorded, and the various data were subsequently collated. In this way a tolerably independent judgment can be formed.

In Sir John Herschel's Cape of Good Hope figure we find:

I. Stars 1–2–19 are on the very edge of A.
II. The line 12–13 does not intersect A.
III. The star 20 is not laid down.
IV. The line 1–10 is not involved *preceding* 1.
V. The star 35 is not laid down on the drawing, although given in the Catalogue.

In general the agreement with Mason's drawing is good for the mass *A* near 1, 2, 19. In the figure given by Mason and Smith:

I. Stars 1–2–19 immersed in A.
II. The line 12–13 does not intersect A, but passes *west* of it by about 15″.
III. The star 20 is not laid down, as it was too faint for Mason's telescope.
IV. The line 1–10 *preceding* 1 is involved in A by a little over 14″.
V. 35 is not laid down in his drawing.

These measures are not made on the engraving representing the nebula as it appears to the eye, but on the contour map (Mason's Plate II). The two plates agree however, but the second is more useful for a purpose like the present one, as it was seen by Mason that it would be.

During his residence at Malta in 1862–4, Lassell presented to the Royal Astronomical Society a figure of this nebula drawn under his direction, which is referred to in the *Memoirs* of that society, vol. xxxiii, p. 121, and figured in Plate I of that work. This figure need not be here given, as essentially the same observations are represented in Lassell's second

figure in the vol. xxxvi of the same series (p. 48 and fig. 32, Plate VIII), which we give below. The first of these figures we may, however, briefly describe in some important points, using Lassell's nomenclature for the stars, as given in the last cited work and Mason's nomenclature for the nebulosity, as in our Index-map.

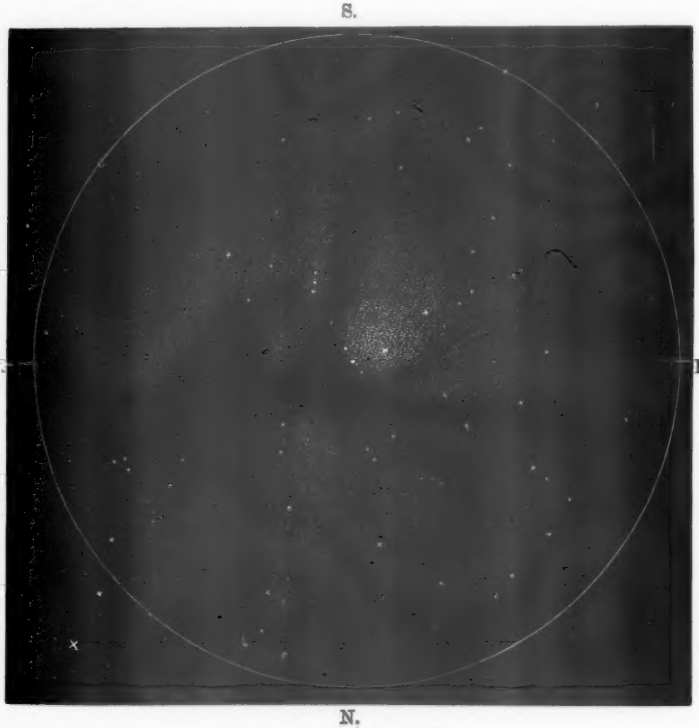

Fig. 5. LASSELL, 1862.

Lassell's first figure.

I. Stars 1, 2, 19 are immersed in the nebula.

II. The line of stars 12–13 prolonged passes through the nebulosity of A. If we draw the shortest line from star 2 to the preceding edge of *A* this line is cut by the line 12–13, prolonged at about one-third its length from its preceding end, and this line is involved in the nebula near 1, 2, 19, for about 30″ of its length.

III. The line from 14 to 20 cuts the line from 2 at about its middle point, and is involved in the nebula near 1, 2, 19 for about 30″ of its length.

IV. The line 10–1 is involved in nebulosity *preceding* 1 by about 16″·6.

V. The line 35–3 is nearly tangent to the *preceding* edge of the nebula A.

Lassell's second figure.

This figure is the result of repeated observations and is to be considered as more trustworthy than the former.

I. Stars 1, 2, 19 are immersed in *A*.

II. The line of stars 12–13 prolonged passes through the nebulosity A *preceding* 1, and is involved in the nebula *A* for about 25″ of its length.

III. The line 14–20 is involved in *A* for about 17″. It is to be noted here that all of A which *precedes* the line 1, 2, 19 is in this drawing considerably fainter than that just on the border of which 1, 2, 19 are situated.

This is not so given in the earlier figure, but probably this second figure represents more exactly the careful observations of Lassell himself. Returning to the second figure we find:

IV. The line 10–1 is involved in nebulosity *preceding* 1 by about 16″·6.

V. The line 35–3 is approximately tangent to the *preceding* shore of A.

From the Harvard College observations by Professor Langley and from sketches accompanying them the following conclusions may be drawn. As remarked by Prof. Langley these conclusions are not of the same weight as the micrometric observations.

I. Stars 1, 2, 19 are *not* immersed in A, but are in the dark channel which, however, is filled with faint nebulosity.

II. The line 12–13 prolonged is not involved in the nebulosity A.

III. Stars 14–20 not laid down.

IV. Line 1–10 *not* involved preceding 1.

V. 35 not laid down.

In the drawing made by M. Trouvelot at Harvard College Observatory*—

I. Stars 1, 2, 19 are immersed in *A*.

II. The line 12–13 does not intersect A, but passes *west* of it by many seconds.

III. The line 14–20 is not involved in A at all.

IV. The 1–10 preceding 1 is involved in A.

V. The star 35 is not laid down.

From the Washington observations it appears that—

I. 1, 2, 19 are immersed in *A*.

II. The line 12–13 prolonged passes through *A*. Half way from this line to the line 1, 2, 19 the nebulosity becomes brighter,

* Annals Harvard College Observatory, vol. viii, plate 32. This figure is not copied, as it is but lately published and is in the hands of astronomers.

and so continues up to 1. That is, the line 12–13 is involved in the fainter nebulosity.

III. The line 14–20 cuts off the *preceding* borders of *A*, but is involved only in fainter nebulosity. It is, however, about tangent to the brighter nebula about 1, 2, 19.

IV. The line 10–1 prolonged is involved in A *preceding* 1.

V. The line 35–3 is almost exactly parallel to the line 12–13 [$p=30°{\cdot}5$], and intersects A near the triple star. This line is tangent very exactly to the preceding edge of the brighter nebulosity about these three stars.

We may make the following summary of the evidence with regard to the position of the triple star relative to the nebulosity.

I. The stars 1, 2, 19 are situated in Herschel's (1837) figure on the very edge of *A*, but in Mason's figure and in his notes, "Things Certain," he places these stars *within* the nebula, and probably a consideration of the two memoirs will result in the conclusion that here Mason was right and that we must suppose the triple star to have been involved in 1837–9. It is all the more proper to come to this conclusion as Herschel does not expressly say that the stars are on the edge, his evidence, at the best, being negative on this point. We therefore may assume with confidence that Mason's figure and memoir give the relative position of these stars and the nebula correctly for 1837–9. It is to be noted here that this position is utterly different from the one derived from the evidence of the earlier observations.

In the absence of *satisfactory* micrometric measures (which indeed are almost impossible to make on this point even with faintly illuminated wires), it may be said that Lassell's (2 figures), Trouvelot's and my own observations agree in this respect with Mason's, allowing for difference of telescopes. We may therefore say with certainty that—

2. *From* 1839 *to* 1877 *the triple star was not centrally situated between the three nebulosities, but was involved in A.* The evidence to be derived from the earlier observations at Harvard College is alone opposed to this conclusion, and these may perhaps be explained by supposing the brightness of the stars 1, 2, 19 to have overpowered that of the nebula near them. At the same time it must be noted that in several respects these observations vary from other later ones, and it is to be remembered that the evidence is here mostly derived from verbal and definite descriptions, and therefore are of greater weight than if deduced only from drawings.

II. The line 12–13, according to Herschel, does not intersect *A*; Mason—does not intersect *A*; Lassell (1)—does intersect *A*; Lassell (2)—does intersect *A*; Langley—does not intersect *A*; Trouvelot—does not intersect *A*; Holden—does intersect *A*.

III. The line 14–20, according to Herschel, cannot be traced; Mason—cannot be traced; Lassell (1)—is involved in *A*; Lassell (2)—is involved in *A*; Langley—is not involved in *A*; Trouvelot—is not involved in *A*; Holden—is involved in *A*.

IV. The line 10–1; the evidence under this head corroborates that under I, except in the case of Harvard College, 1866.

V. The line 35–3: Herschel, star 35 not laid down; Mason, star 35 not laid down; Lassell (1), stars 35–3 about tangent to *A*; Lassell (2), stars 35–3 about tangent to *A*; Langley, star 35 not laid down; Trouvelot, star 35 not laid down; Holden, line 35–3 intersects the fainter nebulosity A, but is about tangent to the brighter part of A near the triple star.

In these points I–V, it appears that there are few discrepancies that the difference in telescopes will not explain, and inference 3 is confirmed.

General notes on the brighter portions of the Nebula.

The *brighter portions* only are considered, in order to avoid as much as possible the discrepancies arising from differences of instrumental power.

In this examination again it will be convenient to derive a series of propositions from each drawing in succession, which can afterwards be compared.

The following analysis may be made of the figure of Herschel (1837).

A. The brightest nebulosity is that *following* 1–2–19, that called B, and that called C. The bounding line of C is strangely different in Herschel and Mason's figures, as remarked by the former. Mason refers in his notes to the outline as given by Herschel.

B. } To understand the distribution of the fainter nebulosity,
C. } a reference must be made to the drawing.

D. Star 12 is on the very edge of the *following* side of B. It might even be supposed to have been intended to be laid down in the channel γ. 13 is immersed, but not much.

E. Star 11 is immersed in *A*.

G. Star 6 in immersed in *A*.

H. Star 5 is on the *preceding* side of *A*.

J. The triangle defined by stars 40, 44, 21 [these stars not being laid down by Herschel makes this inference somewhat doubtful] would be largely free from nebulosity of any considerable degree of brightness.

K. Although the stars of Mason 6 and 4 are not laid down, yet the general agreement of the northern boundary of C near 1, 2, 19 as laid down by Mason and Herschel respectively, is very good.

L. ..... From the engraving I find that about 7^s *preceding* 1 the $\Delta\delta$ of the southern well defined and bright edge of B is $38''$; the width of the channel α is $85''$, and therefore the $\Delta\delta$ of the north edge of C near where star 21 would be, is $123''$.

With reference to the distribution of the nebulosity in Mason's figure we may lay down the following propositions:

A. The brightest nebulosity is that immediately following 1, 2, 19; that surrounding his star 5 [= Lassell No. 18], and that near Mason 6.

B. } The fainter orders of nebulosity are pretty uniformly and
C. } symmetrically disposed about these three brighter centers. This is better understood from the figure than from a description.

D. Stars 12 and 13 are immersed in nebulosity.

E. Star 11 *follows* the edge of the nebula a considerable distance.

G. Star 6 is somewhat immersed in *A*.

H. Star 5 is on the *preceding* edge of *A*.

J. The triangle whose vertices would be in the positions of Lassell's stars 40, 44, 21 is completely filled with tolerably bright nebulosity.

K. The stars Mason 6 and 4 are both immersed in nebulosity, 6 in very faint nebulosity, 4 in a brighter part. The channel α is south of these. The $\Delta\delta$ of 6 and 4 is according to Mason $-63''$ and $-39''$.

L. The $\Delta\delta$ of the south edge of B is about the mean of the $\Delta\delta$'s of stars [Mason] 4 and 6, that is, about $51''$. About 7^s preceding 1, the $\Delta\delta$ of the extreme *northern* limit of C is about $187''$.

In regard to the distribution of the nebulosity in Lassell's figure we may remark:

A. The brightest nebulosity is immediately about and *following* 1, 2, 19.

B. The next order of bright nebula is about stars 35, 36, 37; i. e., just *south* of 1, 2, 19 in the line 1–20.

C. The third order of bright nebulosity is between stars 12, 48, 40 and stars 40, 18.

D. Stars 12, 13, 52 and 53 are immersed in nebulosity.

E. Star 11 is just on the edge of *A*.

F. Star 26 is just on the edge of *A*.

G. Star 6 is nearly in the middle of the dark channel γ.

H. Stars 5, 27, 28 are immersed in the *following* border of B.

J. The triangle 40, 44, 21 is free of nebula.

K. The stars 21, 36, 35 are immersed in C *south* of the channel α.

L. The *southern* limit of B instead of being as in Herschel and Mason's figures over $100''$ *south* of 1, is over $60''$ *north* of it. The $\Delta\delta$ of the *north* shore of C is (roughly) about $-70''$.

Lassell's first figure confirms the above propositions in general. The only changes necessary to introduce are with regard to—

D. 12, 13, 52 on the edge or *following* the edge of B.

F. Star 26 outside of *A*.

H. 5, 27, 28 *follow* the *east* edge of B.

J. The triangle has a patch of faint nebulosity in it (*A'*).

From the MS. observations and drawings of Professor Langley the following conclusions may be drawn:

A. "The brightest nebulosity is about 1" (August 2d). "The region *south* of 1 is judged to be the brightest" (Sept. 10).

B. } See the observations in detail.
C. }

D. Stars 12, 13 are immersed.

E. Star 11 is, if anything, outside of *A*.

F. Star 26 not laid down.

G. Star 6 is, if anything, outside of *A*.

H. Star 5 is near the *preceding* edge of *A*, but immersed.

J. 40, 44, 21 not laid down.

K. Stars 36 ? 35 ? are immersed in C *south* of the channel *a*.

L. No measures possible on the sketches, but it in general agrees with Trouvelot.

From the drawing of M. Trouvelot, which gives the general effect of the nebula to the eye better than any other, we deduce what follows:

A. The brightest part of the nebula is in *A south* following 1, 2, 19.

B. Next in order of brightness is the nebulosity about star 40.

C. The northern borders of C are next in order of brightness.

D. Stars 12 and 13 are immersed in B.

E. Star 11 *follows* the extreme edge of *A* a little (see his outline-map of stars in Annals H. C. Obs., vol. viii).

F. Star 26 is uniformly surrounded by tolerably light nebulosity.

G. Star 6 is within the *preceding* edge of *A* (outline-map).

H. Star 5 is within A (outline-map).

J. The triangle 40, 44, 21 contains a considerable amount of pretty bright nebulosity.

K. Star 21 is on the *northern* border of C. Stars 35 and 36 are not laid down.

The results A, B, ... K, for the Washington observations are laid down in the detailed transcription of those observations (1877, July 30) and need not be repeated here. As to L, we may say that the $\Delta\delta$ of the *north* shore of C, 7^s *preceding* 1 is about $-65''$.

We may summarize the foregoing results as follows: First as to the distribution of the brightest portions (A, B, C). In all of the drawings the nebulosity closely *following* the triple star is of the first order of brightness, while in the Washington observations between 1 and 10 a darker band exists. I am disposed to believe that this band has simply been overlooked, although the two careful figures of Lassell might be supposed to militate against this view. In these no dark band closely *following* 1, exists.

It is possible that the brightness of the stars 1, 2, 19 produces by contrast part of the effect noted.

D. In spite of minor differences the general agreement as to the situation of stars 12 and 13 is good. Lassell's first drawing if not corrected by his second would be difficult to explain in this respect.

E. According to Herschel: star 11 is immersed in A; Mason, star 11 is deeply immersed in A; Lassell, star 11 is just on the edge of A; Langley, star 11 is not immersed in *A*; Trouvelot, star 11 is very slightly immersed in A; Holden, star 11 is on the very edge of the brightest portion, but *follows* the extreme edge a little.

Here Herschel and Mason agree with each other, but differ from the later authorities.

F. According to Lassell: star 26 is just on the edge of *A*; that is, the space between 26 and 5 is totally black. In his first figure 26 is completely free from A, *preceding* the edge; Trouvelot, star 26 surrounded on all sides by uniform nebulosity; Holden, star 26 is within the *brighter* nebulosity of A, whose boundary line runs between 5 and 26 at a distance from 26 equal to about $\frac{1}{5}$ the distance of these stars.

The evidence under this head should be considered in connection with that under H, which is for comparison next given.

H. According to Herschel: star 5 is on the *preceding* edge of *A*; Mason, star 5 is on the *preceding* edge of *A*; Lassell, stars 5, 27, 28 are immersed in the *following* border of B. In Lassell's first figure these three stars are entirely free from nebulosity and *follow* the *east* edge of B; Langley, star 5 is within *A*; Trouvelot, star 5 is within A; Holden, stars 5, 27, 28 are on the *preceding* edge of a fainter strip of nebulosity which begins (at 6) to border A and continues northward beyond 28. The *preceding* edge of the brightest parts of A is very close to 11, a little *east* of 6, about $\frac{1}{5}$ [26—5] preceding 26, etc. If one follows the edge of the nebula A northward from 1 to 5 at the telescope and without previous familiarity with the actual contours, 5 will certainly at the first glance appear to be on or near the extreme edge of A. A little examination shows that the description given in the Washington observations is correct (in 1877), but I have not been able to see how the exact effect given in Lassell's two drawings (by two different observers, be it remembered, at different times) can be produced. At the same time, I have no doubt that the appearance given by Lassell was a true one for 1862–4, and a slight change in the intensity of the nebulosity between 26 and 5 would reduce the nebula as described in the Washington observations to the appearance as given by Lassell. A change in the reverse direction is needed to reconcile the appearances given by Lassell and Mason

While, therefore, no definite conclusion can be reached (as Lassell's drawings of nebulæ in general are of the highest value, being among the very best extant, and as, therefore, we must not only accept them as evidence, but as very positive and conclusive evidence), it is possible that some slight changes of brilliancy (apparently none of situation) may have occurred in the region 28, 17, 13, 26 during the past forty years.

Resuming the previous order:

G. According to Herschel: star 6 is immersed in A; Mason, star 6 is immersed in A, but is very near the edge; Lassell, star 5 is nearly in the middle of the dark channel γ. Both figures confirm this; Langley, star 6 is not immersed in A; Trouvelot, star 6 is within the extreme boundary of A, but close to edge of the brightest part; Holden, star 6 is about midway between the *preceding* edges of the faint nebulosity bordering A, and the edge of the brighter parts of A.

The evidence above seems to me to indicate some decided changes in the brightness [and position] of the edge of A near 6. The first two and the last two authorities agree, and both differ from Lassell and from Langley. Accepting Lassell's authority, some change has here taken place, and it appears that it is connected with the suspected changes *F* and *H*. Langley's observations are not widely different from the later ones, but seem to confirm Lassell's.

J. The triangle defined by 40, 44, 21 is, according to Herschel: free from any marked nebulosity; Mason, completely filled with tolerably bright nebulosity; Lassell, free from nebula (2d figure), free from nebula except *A'* (1st figure); Trouvelot, contains a considerable amount of pretty bright nebulosity; Holden, contains no nebulosity at all bright except *A'*.

Here the various accounts do not agree. Positive evidence is more to be considered than negative, and this triangle in 1837 was probably filled with nebula considerably bright. It is not so now. Trouvelot's figure really agrees with Lassell's and my own, if we correct a little distortion of his figure near this part.

K and L. The point to be settled is, has the channel α remained unchanged? From Herschel's figure we derive the following:

The apex of A' (which in his figure is continuous with B, and is indeed about the brightest portion of the nebula, quite different from now) is about 38 seconds of arc *south* of 1. The $\Delta\alpha$ of this apex is (approximately) -7^s. The width of the channel α at this point is 85 seconds. Hence the *north* shore of C in the R.A. -7^s (from 1) is in $\Delta\delta$ $-123''$.

From Mason's figures (assisted here by the measured positions of stars 4 and 6 of his list) we find the *south* shore of B in $\Delta\delta$ $-51''$; and the $\Delta\delta$ of the *extreme* northern limit of C $187''$. An acquaintance with Mason's memoir is necessary in order to understand the great dependence to be placed on his work.

In Lassell's figure we find star 21 nearly on the *northern* limit of C, and hence in the (measured) $\Delta\delta$ $-73''.9$. In Lassell's figures the part A' is completely detached from B by a wide, black opening. In Trouvelot's drawing A′ is continuous with B, and in my own sketches A′ is indeed separated from B, but by a narrow and not very obvious channel. In respect to the *southern* parts of B we have then the following successive results.

From my own observations the contour of the *north* shore of C near stars 21, 36, 37, 38 is similar to Lassell's, and the $\Delta\delta$ of 21 which gives the $\Delta\delta$ of this north shore is $-65''$. Collecting the various authorities—

Herschel:	$\Delta\delta$ of north shore of C $=-123''$.	
Mason:	$\Delta\delta$ of north shore of C $=-187''$.	(measured.)
Lassell:	$\Delta\delta$ of north shore of C $=-\ 73''$.	"
Trouvelot:	$\Delta\delta$ of north shore of C $=-\ 60''$.	
Holden:	$\Delta\delta$ of north shore of C $=-\ 65''$.	"

The last three authorities may be said to agree: the first two agree in placing the *north* shore of C 1′ or more further *south*. The amount by which it is further to the *south* is probably best given by Mason's figures, for reasons already cited here, and spoken of in general by Herschel himself (*loc. cit.*, p. 11, foot note.)

If there had been no stars (Mason's 4 and 6) near the area in question, this conclusion would not be so definite as it now appears to be. In fact, the positions of these stars were fixed and then the nebulosity was drawn about them. It is certainly not about these stars now.

The space A′ about 7^s *preceding* 1 and between the parallels of $\Delta\delta=0''$ and $\Delta\delta=-38''$ is, according to Herschel, about the brightest portion of the nebula and continuous with the rest of B; Mason, nearly equal to the brightest parts of the nebula, and continuous with the rest of B; Lassell, totally black; Trouvelot, pretty bright, and part of B; Holden, bright, but separated from B by a narrow channel.

In this respect, regarding all the drawings as of equal or nearly equal accuracy, there has undoubtedly been a decided change.

RECAPITULATION OF THE PRECEDING RESULTS.

We may now collect such of the preceding results as we have found important. First it has appeared—

𝔄. *From* 1784, *July* 12 *to* 1833, *the triple star was centrally situated between the three nebulosities.*

Again,

𝔅. *From* 1839 *to* 1877 *the triple star was not centrally situated between the three nebulosities, but involved in A.*

It has previously been seen that each of these propositions rests on a firm basis. Granted that 𝔄 and 𝔅 are correct, I know of but three ways to reconcile the opposing facts:

a. **The triple star has a large proper motion.**
b. **The nebula A has a large proper motion.**
c. **The nebula A is subject to decided changes of brilliancy.**

The first point will be settled by meridian observations now in progress. The relative positions of 1 and the various stars of the group seem to have been unchanged since Mason. If, as is probable, the proper motion of the triple star is small, there remain the two alternatives *b* and *c* to choose between.

We have seen that the evidence with regard to the position of the nebulosity A relative to the star 6, indicates changes in the brightness and position of this part of A. This appears to be connected with changes much less certain near star 5, etc. It has also appeared that in 1839 the nebula B was about the stars Mason 4 and 6. This is confirmed by Herschel's earlier figure, and is totally and entirely different from present appearances. This conclusion is also confirmed by the marked and glaring differences in the description of the region *A′*.

Each of the above inferences rests on undoubted authority, and only cases are included here in which no doubtful points have arisen. It therefore appears to me to be a just conclusion that—

The evidence as recorded *with regard to this nebula indicates marked changes of position or brilliancy, or both, during the period* 1784–1877. The conjecture of Sir John Herschel, "perhaps this singular object has a proper motion," will be recalled in this connection.

I have, in my own mind, no doubt but that the *evidence as recorded*, if thoroughly examined by any competent person will lead to the same conclusion. The examination of many drawings of nebulæ has, however, led me in common with others, to the conclusion that too great care cannot be exercised in interpreting drawings of this class. Drawings and observations made from one point of view have to be interpreted from quite another and a different one, and misreadings and

misinterpretations are likely to occur. It is for this reason that I have given my own observations in detail, so that they may be repeated step by step at any subsequent time; and for the same reason, I have given in full the analysis of the separate drawings so that each point can be verified or rejected by any one who has the original drawings before him.

This method of examining each drawing, deducing from it all the evidence on all the points in question, and then collating the various data under each separate head, not only enables the whole work to be quickly verified, but it enables the person collating the evidence to form the final conclusions with little or no danger of bias or prejudice. The principal question is as to the goodness of the evidence itself. It may be worth while in this case to examine the evidence and to see *what must be rejected* in order to suppose that this nebula has remained *unchanged* from 1784 to 1877. First then, Sir William Herschel speaks of the triple star as being "in the middle" of the three nebulosities on several occasions. Sir John Herschel is explicit as to its being "in the midst" and "exactly in the center" of the "central vacuity." Inference 3 rests on these statements, which could not have been made more definite by Sir John Herschel and which are strongly corroborated by Sir William Herschel. 2 is undoubtedly correct. Hence I believe that the previous inferences regarding the relative motion of the triple star and the nebula should stand, and are correct.

The further conclusions as to change, as I have given them, could have been deduced from the drawings of Mason and Lassell alone, combined with my own observations. The observations of Langley, Trouvelot and Herschel simply corroborate the others in general but are not *essential*. The internal evidence of Mason's paper shows that in spite of his inexperience he was fully aware of the nature of the problem to be solved, and his results are entirely trustworthy. In every point noted as "certain," (and only such points are recorded in the drawing,) his work was verified by his coadjutor, Mr. H. L. Smith. Lassell's drawings are well known, and his series is among the best we have. In this case fortunately we have *two* separate and independent drawings by different hands which support each other. There can be no doubt of their standard character. In regard to my own observations, I am satisfied that they are, in the main and on essential points, correct. The season of 1877 was very unfavorable and the star positions could be improved, but I do not think any error of moment remains. It therefore seems to me that the evidence remaining to be examined is such that it ought not to be rejected, and that the previous conclusions should stand.

ART. XLIX.—*The Northern Part of the Connecticut Valley in the Champlain and Terrace Periods;* by WARREN UPHAM.

A CAREFUL exploration of the stratified drift bordering Connecticut River on both sides, from its source to the north line of Massachusetts, has been made for the geological survey of New Hampshire. Much of the present essay, which is based on this work, will be published, with additional details, in the third volume of the report on that survey.

At the end of the *Glacial period*, this valley, like every other prominent valley in New England, received thick beds of gravel, sand and clay, or fine silt. These were deposited during the *Champlain period*, which embraces the time occupied by the final melting of the great ice-sheet. During the *Recent or Terrace period*, the work of deposition has not been equal to that of erosion, and the rivers have excavated deep and wide channels in the Champlain deposits.* This erosion along Connecticut River has been 100 to 200 feet in depth, and a quarter of a mile to one mile or more in width.

The river-lands here to be considered include the interval, or present flood-plain, frequently known as meadow along the Connecticut, and called bottom-land in the western States; and terraces, which rise in steps on each side of the river, the highest often forming extensive plains. This highest deposit is found to have about the same height upon both sides, and to extend continuously, with nearly the same slope as that of the river, along the whole valley, being broken only by the entrance of tributaries or occasional projecting hills. These terraces are remnants of the river's flood-plain at the end of the Champlain period. The lower terraces agree less frequently in their height on opposite sides of the river, and are commonly short, seldom extending more than one or two miles, and succeeded by others higher or lower. An examination of them over long distances, however, sometimes shows a well-marked series, descending with the river, and recording a height at which during the process of erosion, the river remained nearly stationary in height for an unusual length of time, forming a broad and continuous flood-plain, now interrupted and nearly swept away by the further deepening of the channel. These terraces are almost always level-topped, and bounded at the

* It will be seen that these terms are adopted from Prof. James D. Dana, who has given much attention to surface geology, and has brought into due prominence the abundant deposition of drift, both stratified and unstratified, during the Champlain period. See this Journal, III, v, p. 198; x, pp. 168, 280, 353, 409 and 497. These divisions of Quaternary time are well marked in New England, and apparently in all countries, which have been overspread by ice. They are distinctly characterized as successive periods of glaciation, deposition and erosion.

face by a steep escarpment; and their appearance is sometimes very striking, and even grand, as they rise in gigantic steps on the side of the valley, shaped with a smoothness, order and beauty, which could not be surpassed by art.

The most interesting discovery made during the survey of this valley is, that a massive gravel ridge, often nearly covered by the alluvium of the highest terraces, extends from Lyme, N. H., to Windsor, Vt., a distance of twenty-four miles. It is principally gravel, always waterworn, the largest pebbles being one to two feet in diameter, with occasional layers one or two feet in thickness of coarse sharp sand. These deposits are very irregularly bedded, and a section always shows a somewhat anticlinal stratification, conforming to the slopes of the ridge. Its height is 150 to 250 feet above the river, by which it has been frequently cut through, as well as by tributary streams. This ridge occupies nearly the middle of the valley, and as the river has cut its channel through the alluvium, this has been often a barrier rising steeply upon one side and protecting the plains behind it. In two or three places it has been swept away by the river for a distance of one half mile to one mile, and below these places the terraces show by their coarseness that the ridge has supplied a portion of their material. Similar ridges of gravel have been often described by European geologists, under the various names of *kames* in Scotland, *eskers* in Ireland, and *åsar* in Sweden. They have also been described by geologists in many portions of the northern United States. In both the Connecticut and Merrimack Valleys they extend long distances, but have hitherto escaped notice, owing to the large amount of levelly stratified alluvium, forming the conspicuous terraces and plains, by which these underlying gravel ridges, or kames, are often nearly concealed. The kames are thus shown by their position to be the oldest of our modified drift deposits.

The series of kames already mentioned lie along the middle or lowest part of the valleys, which are bordered by high ranges of hills; but in the southeast part of New Hampshire, in some parts of Maine, and in eastern Massachusetts, where there are only scattered hills, with the valleys not much below the general level of the country, these ridges, of smaller size than in the great valleys, are found extending usually north and south without special regard to the present water-courses.

The origin of the kames has been a question much discussed by European geologists, and the theory commonly accepted on both sides of the Atlantic was, that they were heaped up in these peculiar ridges and mounds through the agency of marine currents during a submergence of the land. Even if such ridges could be formed by this cause under any circumstances,

it seemed impossible to account thus for the kames in the Connecticut and Merrimack Valleys, which, being bordered on both sides by high hills, would have been long estuaries open to the sea only at their mouths, and therefore not affected by oceanic currents. From the position of these peculiar accumulations of gravel, which are overlain by the horizontally stratified drift, the date of their formation is known to be between the period when the ice-sheet moved over the land, and that closely following, in which this more recent modified drift was deposited in the open valley from the floods that were supplied by the melting ice. We are thus led to an explanation of the kames, which seems to be supported by all the facts observed in New Hampshire, and which appears to apply, also, to the similar deposits which have been described in other parts of the United States and in Europe.

At the beginning of the Champlain period, or final melting of the great ice-sheet, its nearly level surface of pure ice lay above our highest mountains. That it overtopped Mt. Washington in New Hampshire, has been recently discovered by Prof. C. H. Hitchcock, the State geologist, who has found transported rocks, and shown that glacial drift, or till, underlies the angular blocks at the summit. The melting of the ice-sheet appears to have taken place mostly upon the surface, which was moulded into basins and valleys; and near the terminal front of the ice, these came gradually to coincide with the contour of the land. Here the surface of the ice became covered with the abraded material which had been contained in its mass, and which was now exposed to the washing of its innumerable streams. Its finer portions would be commonly carried away; and the strong current of the rivers which would be formed near the terminal front of the ice-sheet could transport coarse gravel or even boulders of considerable size. In the lower part of their channels, while still walled on both sides by ice, these glacial rivers deposited materials which had been gathered from the melting glacier. By the low water of winter layers of sand would be formed, and by the strong currents of summer layers of gravel, often very coarse, which would be very irregularly bedded, here sand and there gravel accumulating, and without much order interstratified with each other. Sometimes the melting may have been so rapid that the entire section of a kame may show only the deposition of a single summer, which would then be very coarse gravel without layers of sand. When the bordering and separating ice-walls disappeared, these deposits remained in the long ridges of the kames, with steep slopes and irregularly arched stratification. Very irregular short ridges, mounds, and enclosed hollows resulted from deposition among irregular masses of ice.

The glacial rivers which we have described appear to have flowed in channels upon the surface of the ice-sheet; and the formation of the kames took place at or near their mouths, extending along the valleys as fast as the ice-front retreated. Large angular boulders are sometimes, but not frequently, found in the kames or upon their surface. They appear to have been transported by floating ice. Their rare occurrence forbids the supposition that these deposits were formed in channels beneath the ice-sheet, from which many such blocks must have fallen upon the kames.

The necessity of referring the formation of these gravel ridges to glacial rivers became apparent during the exploration and study of our modified drift in 1875; and in August, 1876, this was announced in a paper "On the origin of Kames or Eskers in New Hampshire."* In this essay it was supposed that these rivers more commonly had their course beneath the ice-sheet, but subsequent examination of the underlying till shows that this was seldom the case, and that the kames were deposited in channels formed on the surface of the ice. Prof. Otto Torell, of Sweden,† had pointed out a division of the till into two members, the lower characterized by its blue color, its compactness and hardness and its glaciated stones; the upper being marked by a yellow and reddish color, comparative looseness of the mass, and its angular or unworn bowlders. This division is found throughout New Hampshire; there being almost always a definite separation, at a depth varying from two or three feet, as is most common, to fifteen or twenty feet, between the upper and lower till. It should be added that the lower till in a majority of cases has no distinct blue tint, but is dark gray; being always somewhat darker than the upper till, which is colored by ferric oxide. The lower till may be distinguished by an imperfect cleavage in planes parallel to the surface, noticeable wherever an excavation has been for a short time exposed to the weather. Before this, Professor James D. Dana had insisted that the deposition of a great part of the till took place in the Champlain period, being dropped from the melting ice-sheet. This suggested the origin of the upper till, and an explanation of its difference from the lower till; the latter being the ground-moraine, while the former appears to have been material contained in the body of the ice-sheet, and allowed to fall loosely on the surface when this melted. As the kames overlie both members of the till, they plainly were deposited in superficial ice-channels.‡

* Proceedings of the American Association for the Advancement of Science,' vol. xxv.

† See this Journal, III, xiii, p. 77.

‡ Similar conclusions respecting the origin of the kames had been reached by other observers, but were unknown to me when my views were proposed in August, 1876. Probably the first of these was Professor N. H. Winchell, State

When the glacial river entered the open valley from which the ice had retreated, its current was slackened by the less rapid descent, causing the deposition successively of its gravel, sand and fine silt or clay. The valleys were thus filled with extensive and thick deposits of modified drift, which took the same slope with the descending floods, increasing in depth in the same way that additions are now made to the bottom-land, or intervals, of our large rivers by the annual floods of spring.

The terraces began to be formed as soon as the supply of material became insufficient to fill the place of that excavated by the river. We must suppose that this process of erosion was slow, allowing the river to continue for a long time at nearly the same level, undermining and wearing away its bank on one side, and depositing the material on the opposite side, till a wide and nearly level lower flood-plain would be formed, bordered on both sides by steep terraces. When the current became turned to wear away the bank in the opposite direction, a large portion of this new flood-plain would be undermined and re-deposited at a lower level; but the direction of the current's wear might be again reversed in season to leave a narrow strip, which would then form a lower terrace.

In placing theories before our description of this valley, their first order has been reversed, since these explanations have been arrived at or confirmed by long study of these deposits in this valley and throughout New Hampshire.

The sources of Connecticut river are a series of four lakes, the highest of which, covering only a few acres, is 2,550 feet above the sea. The lowest of the series is Connecticut Lake, three square miles in area, 1,618 feet above the sea. Heights of the river, with distances from Connecticut Lake, are as follows: Mouth of Hall's stream, 15 miles, 1,085 feet above sea; at Colebrook, 24 miles, 1,010; at North Stratford, 37 miles, 891; at Groveton, 49 miles, 854; at Lancaster, 56 miles, 835; mouth of John's river, 63 miles, 830; at Upper Waterford, 74

Geologist of Minnesota, who held this opinion as early as 1872. See Proc. Amer. Assoc. for Adv. of Science, vol. xxi, 1872, p. 165; Geology of Minnesota, First Annual Report (for 1872), p. 62; and same, Report for 1873, p. 194. In the revised edition of Geikie's Great Ice Age, published in London in the winter of 1876–77, this distinguished glacialist retracts his former opinion that the kames were heaped up by marine currents, and attributes their formation to sub-glacial rivers. See work cited, pp. 217, 237, 240, 243, and 478. By p. 414 it appears that this theory was first proposed by Mr. D. Hummel of the geological survey of Sweden, in 1874; and on page 415 allusion is made to a recent paper by Dr. N. O. Holst, also of Sweden, in which the kames have been explained in the same manner as in this article. On pp. 49 and 50 large rivers are mentioned as having been observed in summer upon the surface of Arctic glaciers. These would be formed on a grander scale in the Champlain period, when the melting of the ice appears to have been much more extensive and rapid than is anywhere to be seen at the present day. The small sub-glacial tunnels which probably existed through the glacial period, would be insufficient to discharge these increased floods, and would become obstructed by the detritus which they brought.

miles, 674; mouth of Passumpsic River, 83 miles, 460; at Wells River, 95 miles, 407; at Hanover, 130 miles, 373; at White River Junction, 134 miles, 333; at Windsor, 146 miles, 304; at Bellows Falls, 170 miles, fall from 283 to 234; at Brattleboro', 192 miles, 200; at South Vernon (Massachusetts line), 202 miles, 180.

The general course of the river to the mouth of Hall's stream is S. 60° W. High wooded hills border the valley which is destitute of modified drift for half of the way. The largest alluvial area is on Indian stream, and the highest terraces are of coarse gravel, 30 to 40 feet above the river.

From the mouth of Hall's stream to that of John's River, at the head of Fifteen-miles Falls, the general course is S. 13° W., with a descent in nearly fifty miles of only 255 feet, one-fifth of which takes place in the first two miles, and two-fifths more in the nine miles between Columbia bridge and North Stratford. Below the first two miles the modified drift is continuous along this whole distance; and, including both sides, it is usually a half mile to one and a half miles wide. It is very simple, having two heights, and consisting of the present flood-plain, bordered by remnants of that which filled the valley in the Champlain period. This ancient flood-plain is represented by a lateral terrace of sand or fine gravel, from 40 to 120 feet above the river, usually remaining at both sides, and in many places forming considerable plains.

At Colebrook we find an interesting gravel ridge or kame, portions of which remain north of the junction of Beaver brook and Mohawk River, but most noticeably west of the village, extending nearly a mile parallel with the river. Its height is about seventy feet above the river, and fifty above the low alluvium on each side. Its material is the same as that of the long kame farther south in this valley, being principally coarse water-worn gravel, with abundant pebbles six inches to one foot in diameter. In Stratford and Brunswick both heights of the alluvium are well shown, the highway being on the upper terrace and the railroad on the meadow. At Lancaster the upper terrace of Connecticut River is only fifteen or twenty feet above the present flood-plain. The only higher modified drift has been brought down by tributaries. Part of Lancaster village is built on one of these deltas, formed by Israel's River on its south side, fifty feet above the terrace of the main valley. This delta sloped rapidly westward, and formerly occupied the whole area of the village; a portion of it, twenty feet lower than the former, remains at the cemetery opposite the court-house.

Between South Lancaster and Fifteen-miles Falls the broad river-plain is unterraced. It seems probable that a lake ex-

isted here while the original high plain northward was being deposited. When this was channelled out by the river, so as to leave only terraces as we now see them, the materials excavated were sufficient to fill up the lake. It would be interesting to know the depth of the stratified drift in this basin; it is probably deeper than the height of the highest terraces northward above the river.

From the mouth of John's River, the Connecticut has a rapid descent for twenty miles, falling from 830 to 460 feet above the sea. Its general course is deflected to S. 70° W. along this distance, beyond which the direction of the upper is again followed in the lower valley, with but slight deviation, to Massachusetts line. The noticeable features of the valley along these rapids are, that it is deep and narrow, with sloping sides of till, and destitute of the level alluvial terraces and intervals which occupy a large width everywhere else along the river. Where any modified drift does occur, it is coarser than usual, being generally gravel, sometimes imperfectly rounded or water-worn, and its surface has commonly an irregular slope. The river flows in a nearly continuous descent over coarse till, showing abundant bowlders, but with scarcely any exposure of solid ledges. The falls farther south are produced by ledges; and the channel, except at such falls, is composed of gravel, sand or silt, which is also the case along the nearly level upper valley. The irregular surface left by the ice has been here reduced to a channel of nearly regular slope with no abrupt falls, cut through the till, which still covers the ancient bed in which the river flowed before the glacial period.

In a direct distance of 119 miles from the mouth of Passumpsic River, which is near the foot of these rapids, to the Massachusetts line, the river flows 137 miles, descending from 460 to 180 feet above the sea, or two feet to the mile. The principal falls in this distance are Beard's falls, at Barnet, five feet; McIndoe's falls, ten feet; Dodge's falls, three and a half miles south, five feet; at Woodsville, about ten feet; White River falls, between Hanover and White River Junction, thirty-five feet; Sumner's or Quechee falls, two miles below the mouth of Quechee River, five feet; and Bellows Falls, forty-nine feet, —making a total of 119 feet, and leaving an average descent, excluding falls, of one and one-sixth feet per mile.

The modified drift of this lower valley is everywhere well developed, and occurs in extensive terraces and various heights, three or four often on each side, the upper one being usually from 150 to 200 feet above the river, while the lowest is the interval or meadow. The largest plains are expanses of the upper terrace or of still higher tributary deltas. These areas are generally of a clayey, moist, productive soil quite in con-

trast with the dry sandy plains of Merrimack River and other parts of New Hampshire. The most extensive intervals or meadows are between Woodsville and Bradford, twelve miles long and one half to one mile wide, including the Lower Coös intervals of Newbury, Haverhill and Piermont; and in Charlestown and Rockingham, six miles long and half a mile wide. In addition to these, smaller areas, up to a mile or more in length and a few rods to a half mile wide, are of common occurrence. These bottom-lands are very fertile, being composed of the finest silt, and enriched every year by a coating of mud from the turbid freshets of Spring. Many of the lower terraces which are not overflowed are of the same material; but the higher terraces usually show some intermixed sand or fine gravel.

The greatest widths of modified drift that can be measured in this valley on the west side of New Hampshire, are in Haverhill and Newbury, two miles, and in Hinsdale and Vernon, two and a half miles wide. The average width is fully one mile. The narrowest places are at Shaw's Mountain, near the south line of Bradford, and at Barber's Mountain, in Claremont, both of which occupy the middle of the valley, with narrow belts of alluvium on each side; at the west side of Rattlesnake Hill, Charlestown; and at the south end of Wantastiquit Mountain, below Brattleboro'. We do not discover, however, at these places or elsewhere, any evidence of former barriers, which could have made the valley a series of lakes. The vast amounts of modified drift which accumulated here appear to have been rapidly deposited from the immense floods supplied by the melting ice-sheet. Such deposits, for which there appears no other adequate cause, should rank with the till, striæ and embossed ledges, as proof of a former continental glacier.

At Woodsville a great depth of material was brought into the valley by the Lower Ammonoosuc and Wells Rivers. The former stream has cut its channel 200 feet deep through its delta, wide areas of which still remain on both sides. An old outlet of Wells River may be seen on its north side, one mile above its mouth, occupied at the close of the ice-period until it cleared away a hundred feet or more of modified drift from the pre-glacial rocky bed in which it now flows. A well marked kame occurs here, commencing in Bath half a mile northwest from the Narrows. It has been cut through by the river, and appears on the east side of the railroad at and above the junction, and again at the southwest side of Wells River Depot, being more than a mile long. It is composed of coarse gravel and sand, anticlinally stratified, with varying height from 80 to 150 feet above the river. It is well shown by cuttings, but otherwise might escape notice, as most of it is partially or

wholly concealed by the ordinary alluvium. In the twenty-four miles from Wells River to Lyme no similar ridge is found.

In Thetford and Lyme we come to an abrupt change in the height of the upper terrace-plain. This slopes in thirty-three miles between the mouth of Passumpsic River and the south line of Orford, from 650 to 440 feet above the sea, gradually declining from 190 to only 60 feet above the river. At North Thetford this line of the highest terrace suddenly rises to 525, and in a mile and a half farther south to 545 feet. This formation is well shown through Thetford, with remnants in Lyme, and continues well developed and nearly level for twenty-five miles to Windsor, varying from 560 to 500 feet above the sea, and from 150 to 220 feet above the river. It forms extensive terraces or plains on one or both sides along the whole distance and is clearly the original flood-plain of the river. Frequent delta-terraces rise above it, sometimes 100 feet higher, being more than 300 feet above the present river channel. It is a notable coincidence, that along this same distance we have a continuous kame, occupying the center of the valley, commonly rising somewhat above the highest plain, but not seldom entirely covered by it. Super-position and conformable stratification show the fine material of the terrace-plain to have been deposited upon this kame or gravel ridge, which beforehand extended like a windrow along the empty valley. To the south from Windsor the highest terrace shows a somewhat regular slope, descending with the river, and preserving a height about 150 feet above it.

This high and continuous flood-plain, extending from Thetford to Massachusetts line, seems to have been formed during a gradual and slow melting of the ice along this distance. It would appear that the greater part of the depth of ice, as far northward as to the Passumpsic River, had been melted in the last part of this time, sending down its floods laden with gravel to form the kame. A comparatively shallow mantle of ice remained, and when the melting advanced to the north from Thetford and Lyme this disappeared too rapidly to give time for the formation of a kame, or the deposition of a high flood-plain.

In Norwich we find an interesting example of a well marked ancient river-bed high above its present level. This extends two miles from Pompanoosuc River, one-third of a mile above its mouth, to the bend of Connecticut River a half mile south of Tilden pond, which occupies a depression of this old channel. Its highest point, from which there is a gradual descent both ways, is 520 feet above the sea or 145 feet above the river. On the east side of this ancient channel is the steep gravel kame, which for a while turned the Pompanoosuc River in this course, till a direct passage was cut through its ridge.

Two miles north of Hanover the Connecticut River has cut through the kame, and thence flows close on its west side to White River Falls. Along this distance of four miles we find the high plain well developed in New Hampshire, averaging three-fourths of a mile wide. Hanover common, 545 feet above the sea, and 172 above the river, represents its greatest altitude. In digging the first well at this place (near the residence of Professor H. E. Parker), a large log was found in this alluvium forty feet below the surface, but no prospect of water, which caused this site, selected for the buildings of Dartmouth College, to be abandoned, and led to their location farther east, upon coarse glacial drift. This log shows that the glacial age had here been succeeded by a temperate climate, under which forests grew again upon the land; and that floods, sent out freighted from the melting ice-sheet, which still remained farther north and on the highlands, brought down drift-wood to be buried with their alluvium. It was not till considerably later that the river ceased its work of accumulation and began to cut its present channel.

Near the south line of Lebanon, east of Sumner's Falls in Plainfield, and at several places in Cornish, we find banks of sand, or dunes, destitute of vegetation, and blown in drifts by the wind. These vary in height from a few feet to 100 feet above the highest terrace, from which they appear to have been carried up by the prevailing northwest winds. Southward through New Hampshire they are found in many places on the east side of this valley, but none were seen in Vermont.

From Lyme to Windsor we find a continuous gravel ridge or kame, extending twenty-four miles along the middle of this valley, with its top from 150 to 250 feet above the river, or from 500 to 600 feet above the sea. The gravel, which always forms the principal part of the ridge, varies in coarseness from layers with pebbles only one or two inches in diameter, to portions where the largest measure one and a half or two feet. The finer kinds prevail; and the channels of brooks cutting through the ridge frequently show no pebbles exceeding one foot in size. All the materials of this kame, and of its remnants southward, are plainly water-worn and stratified.

Large and unworn bowlders, which could not have been brought in the same way with the gravel and sand, occur very rarely upon or in the Connecticut kame. The only instance of this discovered was three fourths of a mile south of Pompanoosuc River, at the point where the kame reaches its greatest height above the sea. Two angular bowlders, each of five feet dimension, were found here at the top of the ridge, one lying on the surface, and the other partly imbedded. Several miles at least of journey on foot along the top of this ridge, and the examination of many sections where the river or its tributaries

have cut through it, failed to reveal other bowlders of this kind.

One or both sides of this kame are generally covered by the alluvium of the upper terrace; but its top usually projects in a long, rounded ridge, 10 to 30 feet above the adjoining highest plain. At one place, east of Hartland Depot, this plain has been swept away from both sides, and the kame forms a conspicuous steep ridge 125 feet in height. Wherever it is exposed, it is readily recognized by the pebbles which strew its surface, and which are very rarely found in the ordinary modified drift of the valley.

The most important feature of this kame, if we compare it with others in New Hampshire, is, that along its entire extent it constitutes a single continuous ridge, which runs by a very direct course nearly in the middle of the valley, having no outlying spurs, branches, parallel ridges, or scattered hillocks of the same material associated with it. In calling it continuous from Lyme to Windsor, however, it is not meant to imply that it is now entire, since it has been frequently cut through and considerable portions swept away by the main river and by tributary streams; but that so much of it remains as to make it certain that it originally formed an unbroken ridge. The portions now separated by gaps always lie in a continuous line.

Probably a similar ridge once existed along the valley southward, though now shown by only a few fragments. These occur in Charlestown between Springfield Depot and the Cheshire bridge; at Bellows Falls, where a remnant forms the pine-covered plateau, used as a picnic ground, in the north part of the village; in Dummerston, a third of a mile southwest from the depot; and in Brattleboro', at the north side of West River, lying on ledges between the railroad and highway.

Near Bellows Falls, Cold and Saxton's Rivers have brought down large amounts of modified drift seventy-five feet above the normal high plain. The delta of the former has been eroded so far as it occupied the main valley, but the escarpments thus formed remain at the mouth of the valley of Cold River, from 100 to 200 feet high. On the south side of Saxton's River a considerable part of its delta remains, and the upper terrace is increased in height by this cause for two miles south. The excavation of this delta by Saxton's River has formed a most interestingly terraced basin, situated less than a mile south from Bellows Falls Junction. On both sides of this river, and crossed by a road, is an interval about one fourth of a mile in diameter. Around this on all sides are ranged terraces, which rise in succession like the seats of an amphitheater, the highest on the northwest being 220, and on the south 200 feet above the arena below. They do not, however, show a perfect regu-

larity either in correspondence of height or in continuous extent, and no single section would embrace all of the eight distinct and separate terraces which were noted on each side of the river.

The most extensive plain on Connecticut River in New Hampshire or Vermont is in Hinsdale, being three miles long, with a width decreasing from two miles to two-thirds of a mile. The road from Hinsdale to Brattleboro' passes over the south end of this plain. Here its height is 350 feet above the sea, or 165 above the Connecticut at the mouth of Ashuelot River. It is mainly composed of sand, nearly level, but with a slight slope to the west and south, being as usual towards the river and in the direction of its course. Its northern portion changes to gravel which becomes coarse on the southeast side of Wantastiquit Mountain, containing pebbles one foot or sometimes a foot and a half in diameter. The position and slope of this plain show that it was not deposited wholly from currents of the main valley, but that a considerable portion was contributed from the melting of the ice-sheet east of this mountain.

ART. L.—*Descriptions of two new species of Fishes (Macrurus Bairdii and Lycodes Verrillii) recently discovered by the U. S. Fish Commission, with notes upon the occurrence of several unusual forms;* by G. BROWN GOODE and TARLETON H. BEAN.

AMONG the many interesting discoveries made during the present summer by the United States Fish Commission (Prof. S. F. Baird, Commissioner) is that of a species of *Macrurus* believed to be undescribed. A single specimen was taken in a trawl net, August 19, 1877, on the voyage of the U. S. Steamer "Speedwell" from Salem to Halifax. It was found in the Gulf of Maine, forty-four miles from Cape Ann (east ½ south) in 160 fathoms, muddy bottom (locality 35). Two members of this family are included by Professor Gill in his Catalogue of the Fishes of the East Coast of North America (Washington, 1873). One, *Coryphænoides norvegicus*, has been recorded only from Greenland and the northern and western coasts of Norway. The other, *Macrurus rupestris*, has much the same geographical range: a fish found floating at sea near Gravesend, N. Y., in 1876, and now in the U. S. National Museum, has been identified with this species.

The genus *Macrurus*, auct., has been subdivided into three, viz: *Macrurus*, *Coryphænoides* and *Malacocephalus*. The most important diagnostic character given by Dr. Günther as sepa-

rating *Macrurus* from the other genera is the joining of the ridge of the suborbital ring to the angle of the preoperculum as in *Scorpænidæ* and *Cottidæ*. This character does not hold good in the species here under consideration, which in all other respects agrees with *Macrurus*, as defined in Günther's Catalogue of Fishes in the British Museum.

The closest affinities of *Macrurus Bairdii* are with *M. sclerorhynchus*, described by Valenciennes from the Canary Islands. Its relations to this species and to the other representatives of the family in North America are shown in the following table:

	Macrurus Bairdii.	*Macrurus sclerorhynchus.*	*Macrurus rupestris.*	*Coryphænoides? norvegicus.*
Snout.	Sharp, conical, quadrate, shorter than eye, less than one-third of head.	Sharp, trihedral, shorter than eye, which is two fifths of head.	Sharp, triangular, as long as eye.	Obtuse, obliquely truncated.
First Dorsal.	Second spine denticulated from base to tip, not extending to origin of second dorsal.	Second spine denticulated, extending far beyond origin of second dorsal.	First spine denticulated only towards the top.	First spine denticulated anteriorly.
Vent.	Under middle of first dorsal.	Behind vertical from last ray of first dorsal.	Behind vertical from origin of second dorsal.	Before vertical from origin of second dorsal.
Scales.	Spiny. Median row of spines forming keel upon scales of head and upper anterior portion of body.	Spiny. Median row of spines forming keel.	Each with a strong longitudinal keel terminating in a point.	Spiny, without keel.
Transverse rows of scales	6+19 or 20.	5+21 or 23.	5+	4 or 5 + .
Radial formulæ.	D. II. 11. 137. A. 120. V. 7.	II. 9 or 11. 87. 72.	11. 124. 148. 8.	11 + . 8.

Macrurus Bairdii, sp. nov.

Extreme length of specimen described,* 0·296 m. (11·7 inches). Body tapering from first dorsal to tip of tail, much compressed posteriorly, its greatest height over origin of pectorals (0·037 m.) contained eight times in length; its greatest width at same point (0·022 m.), contained 13 times in length.

Scales irregularly polygonal, the free portions covered with transparent, vitreous spines, arranged in from ten to twelve irregular longitudinal rows. On head, and upper part of body, in advance of first dorsal, the median row of spines is the most prominent, and presents the appearance of a low median keel.

Lateral line nearly straight, formed by a smooth groove which replaces two or three median rows of spines of each

* Cat. No. U. S. National Museum, 21,014.

scale. Number of scales in lateral line, 152; six transverse rows above it, and nineteen or twenty rows below it, counting from vent obliquely backward.

Head.—Greatest length (0·045 m.) equals distance between first and twenty-third anal rays, and is contained six and one-half times in extreme length. Greatest height, at posterior margin of orbit, (0·028 m.) greater than width at same point (0·023 m.), and contained one and four-seventh times in length of head. Width of interorbital area (0·012 m.) equal to vertical diameter of orbit (0·012 m.), and almost equal to length of snout (0·013 m.) and length of maxillary (0·013 m.). Length of post-orbital region (0·017 m.) about equal to horizontal diameter of orbit (0·016 m.). Length of operculum (0·007 m.) about half the length of mandible (0·015 m.).

Snout sharp, a front view presenting four ridges radiating from the tip at right angles to each other, the lower one being merely a fold in the skin of the under surface of the head. The horizontal ridges are continued into the ridges upon the suborbitals. Ridge extending backward from tip of snout upon top of head is lost in the interorbital space. Branches of the horizontal ridges are continued upon the upper margins of orbits, and there disappear. Nostrils immediately in front of orbit, the posterior pair much the longer.

Mouth situated entirely on lower side of head; symphysis of lower jaw in vertical from anterior margin of orbit, and articulations of mandibles in vertical from posterior margin of orbit; width of cleft of mouth (0·012 m.) equal to distance between symphysis of maxillaries and line connecting their articulations. Upper jaw protractile vertically. Barbel 0·005 m. in length.

Teeth conical, somewhat recurved, of nearly uniform size, arranged in villiform bands. Palate smooth.

Distance of first dorsal from snout (0·057 m.) about four times the length of its base (0·014 m.), and from anterior margin of orbit equal to length of head. First spine very short (0·002 m.), not much longer than the teeth of second spine. Second spine in length (0·032 m.) twice horizontal diameter of orbit, stout, its anterior margin armed from base to tip with fifteen teeth pointing upward, the uppermost being longest and most slender: its length to tip of filament (0·037 m.) is almost equal to distance from origin of first to origin of second dorsal (0·038 m.), this tip when laid back reaching almost to second dorsal. Rays decreasing regularly in length so that, when the fin is upright, its shape approximates that of a right angled triangle, the hypothenuse of which is the second dorsal spine and its perpendicular side a line touching the tips of the rays.

Length of base of second dorsal (0·204 m.) less than that of the anal, its origin over the 30th scale of lateral line. Length

of longest ray (in posterior third) 0·004 m., which is less than length of barbel. All rays very feeble. Membrane scarcely perceptible.

Distance of anal from snout (0·070 m.) three and four-fifth times in its length of base, its origin under 18th scale of lateral line. Length of first ray (0·006 m.) one-half the length of tenth ray (0·012 m.), and three times the length of last ray (0·002 m.), the length of rays increasing to a point beneath anterior part of first dorsal, and thence gradually decreasing to tip of tail.

Distance of pectoral from snout (0·048 m.) four times width of interorbital area; its length (0·029 m.) twice the length of mandible. Insertion above the middle of the depth of the body, on a level with center of orbit, its third ray longest, its tip reaching to vertical from base of fourth anal ray.

Insertion of ventral behind pectoral and almost under that of first dorsal; its distance from snout (0·053 m.) slightly exceeding twice its length (0·025 m.). Tip of ventral filament reaches to base of third anal ray.

Radial formula: D. II, 11. 137; A. 120; P. 15; V. 7.

Color: Ground color, light brownish gray; under parts, silvery; belly, darker, bluish. Under surface of snout, pink, as is also the first dorsal except spines. Spines of dorsal, ventral and anterior anal rays, blackish. Throat, branchiostegal membrane and isthmus, rich deep violet. Sclerotic coat, green. Eyes, very dark blue.

Spermaries well developed, but milt not mature. Individual apparently adult.

This species is dedicated to Professor Spencer F. Baird, LL.D., Assistant Secretary of the Smithsonian Institution, Director of the U. S. National Museum and U. S. Commissioner of Fish and Fisheries.

Another interesting form is a species of *Lycodes* taken in the trawl thirty miles south of Cape Negro, N. S. (localities 44 and 45), in ninety fathoms, fine sand and mud bottom, and twenty-seven miles south of Chebucto Head, Halifax, (locality 83) 101 fathoms, fine sandy mud. Five specimens (Cat. No. U. S. Nat. Mus. 21,013) were taken in the first locality and one (No. 21,015) in the latter.

Eleven species of this genus have been described, eight of which are found in arctic seas, three in antarctic, the latter being separated by Dr. Günther into a distinct section of the genus. The form under consideration is distinguished by (1) its elongated form, which it shares, with *L. Sarsii;* (2) the great proportional length of the maxillaries; (3) by the presence and arrangement of scales; (4) by various proportions of parts which distinguish it from one or all the allied species; (5) the presence of five rays in the ventral fin, and; (6) by coloration.

Lycodes Verrillii, sp. nov.

The extreme length of specimen described 0·127 m. (five inches).

Body more elongate than in any other described species of that section of the genus occurring in arctic seas, except *L. Sarsii* Kroyer: its greatest height (0·010 m.) equal to its greatest width between pectorals (0·010 m.) and nearly one-thirteenth of its total length.

Distance of vent from ventrals (0·023 m.) slightly greater than length of head (Om. 022), which is contained about five and two-third times in total length. Distance of vent from snout (0·041 m.) about one-third length of body.

Head, body and fins enveloped in tough lax skin.

Scales cycloid, circular and ovate, 0·00025 m. to ·00035 in diameter, with numerous concentric striæ, and with about eighteen lobes upon margin, the whole perrimeter being lobed: they are deeply imbedded in the skin at distances from each other equal to their own diameters: they are most numerous upon the upper half of the body, and extend upon the base of the dorsal; very few upon the lower half of the body; and are absent from the anal fin.

Head much depressed, its width (0·014 m.) considerably greater than its height (0·010 m.) which equals length of post-orbital portion of head (0·010 m.) and double the width of the inter-orbital space (0·005 m.). Length of maxillary (0·011 m.) is half the length of the head (0·022 m.): the maxillary extends nearly to the perpendicular from the posterior margin of the orbit. Diameter of orbit (0·004 m.) is half the length of snout (0·008 m.).

Viewed from above the snout is somewhat obtusely rounded, and a line drawn through the center of the eyes would form with the sides of the snout a figure approximating in shape an equilateral triangle, the angle of the snout being rounded.

Upper jaw far overlapping under jaw; gape extending from ventral to center of orbit.

A series of large pores, six on each side, extends backward from nostril toward angle of operculum, following line of upper jaw at a distance above it about equal to diameter of pupil. The fourth of this series, counting backward, is under the center of orbit, the last is situated about two-thirds of the distance from snout to angle of operculum.

A similar series, seven on each side, follows line of lower jaw from its symphysis obliquely upward toward angle of operculum, in such direction that if the maxillary row were continued by the addition of a single pore to the series, the two lines would intersect. A line connecting the fourth pore of the one series with the fourth pore of the other would intersect the

articulation of the jaws. The first four pores of the mandibular series are slit-like; all the others in both series are circular or nearly so, their diameter equal to one-third to one-half that of the pupil. The profile of the head resembles that of *Zoarces anguillaris;* the top of the post-orbital tract is on a level lower than that of the top of eye, the outline of the head then rising to a point over the center of the orbit, thence sloping abruptly to the snout.

Cleft of mouth horizontal, in width equal to post-orbital length of head (0·010 m.), also to distance from snout to angles of gape.

Nostrils at extremities of fleshy tubes, the length of which is equal to the diameter of the largest pores.

Teeth in lower jaw in two rows and nearly uniform in size, in upper jaw, in a single row, some larger ones near symphysis with patches of smaller ones behind them. About seven teeth on the vomer. A single row of teeth on palatines. All the teeth are curved.

Gill openings narrow; gill membranes attached to isthmus.

Distance of dorsal from snout (0·033 m.) one and one-half times the length of head (0·022 m.).

Distance of anal from snout (0·045 m.) twice the length of head.

Dorsal and anal fins are about equal in height, with even margins, not differentiated from caudal; the rays increase somewhat in length toward extremity of tail, though the fins do not increase in height.

Distance of pectoral from snout (0·023 m.) about equal to length of head, twice length of pectoral (0·011 m.) and more than three times breadth (0·007 m.). Pectoral extends to vertical from base of second dorsal ray.

Distance of ventrals from snout (0·021 m.) less than length of head (0·022 m.), their length (0·002 m.) less than one-fourth the length of pectorals, placing this species in the first section of the genus as defined by Dr. Günther.

Radial formula: D, 92; A, 88; P, 15; V, 5. Color: Body above lateral line light grayish brown with numerous minute circular dots marking the position of the scales; below lateral line pearly white. Brown irregular patches upon the sides, bisected by the lateral line, the part lying below lateral line is of the dorsal hue, that above a darker shade of the same color, and exhibiting the white dots already described. These brown patches are seven to ten in number on each side, in some specimens regularly alternating with each other, in others approximating each other in such manner as almost to form broad irregular bands across the back. A spot of brown upon the tip of tail. Abdominal region livid blue In a very small specimen* the brown patches are for the most part circular and are not confluent over the back.

* 21,015 of the U. S. National Museum Catalogue.

Four of the six specimens taken had a lernean parasite on the gills.

This species is dedicated to Professor Addison E. Verrill, of Yale College, who has been in charge of the invertebrate work of the U. S. Fish Commission since its organization.

In addition to the above species a number of new or unusual forms have been taken or observed, among which may be specified the following:

Alutera cuspicauda Dekay. A specimen of this species which has not before been recorded north of Cape Cod, was taken in Halifax Harbor, September 6.

Euchalarodus Putnami Gill. Several specimens of this uncommon species, which had been taken in Salem harbor in winter, were found in the collection of the Peabody Academy of Sciences.

Myzopsetta ferruginea (Storer) Gill. Taken in Massachusetts Bay in forty-five to ninety fathoms; near La Have Bank in ninety fathoms; and at the mouth of Halifax Harbor in sixteen to eighteen fathoms.

Pleuronectes glaber (Storer) Gill. Several specimens, taken in Salem Harbor, Mass., were noted in the collection of the Peabody Academy.

Glyptocephalus cynoglossus (Linn.) Gill. This fish, the Craig Flounder or Pole of Europe is cited by British authors as one of the rarest of arctic flounders. It has hitherto been unknown to the coast of North America. At least one hundred specimens have been secured, representing great variety of form, age and other conditions. The species was first taken August 6, 1877, off Salem in forty-five fathoms. It has since been secured near La Have Bank in eighty-eight fathoms, and in Bedford Basin, Halifax, in from twenty-five to thirty-five fathoms.

Hippoglossoides platessoides (Fabr.) Gill. Taken on La Have Bank in eighty-eight fathoms. Heretofore recorded only from Greenland. It is not identical with *H. limandoides* as suggested by Dr. Günther.*

A species of the genus *Hippoglossoides* which is distinct from *H. platessoides* and may prove to be identical with the *H. limandoides* of Günther has been taken in company with *Glyptocephalus scynoglossus* in Bedford Basin, Halifax.

Rhinonemus caudacuta (Storer) Gill. Several specimens taken in Massachusetts Bay, and on La Have Bank.

Cryptocanthodes maculatus Storer. One specimen taken in Massachusetts Bay, August 13, 1877, in forty-eight fathoms.

Eumesogrammus subbifurcatus (Storer) Gill. A single specimen was taken August 25, 1877 in the mouth of Halifax Harbor in sixteen fathoms.

* Cat. Fish. Brit. Mus., iv, 1862, p. 405.

Stichæus punctatus (Fabr.) Reinh. A single specimen of brilliant scarlet color, was taken in the same locality with the preceding.

Eumicotremus spinosus (Fabr.) Gill. One specimen was dredged by the U. S. Fish Commission six miles off Half Way Rock, Salem, Mass., August 10, 1877, in thirty-five fathoms. "It is of very rare occurrence. Two specimens were dredged in 1861 by Professor Verrill, off Anticosti in ten fathoms, and another was taken by U. S. Fish Commission at Eastport, (Maine), in 1872." (*Putnam.*)

Aspidophoroides monopterygius (Bloch) Storer. Up to the time of the visit of the U. S. Fish Commission to Salem, this species has been very rarely taken south of Greenland, and that mainly from the stomachs of cod, haddock, halibut and other fishes. Several specimens were dredged by the Commission at Portland and Eastport, Maine. Many specimens were taken in Massachusetts Bay, often a dozen coming up in a single haul of the trawl.

Icelus uncinatus Reinhardt. Trawled in considerable numbers in Massachusetts Bay in forty-two to ninety fathoms. One or two were secured by the U. S. Fish Commission at Eastport, Maine, in 1872. No other specimens are known to have occurred on the coast of North America.

Triglops, sp. An undetermined member of this genus, has been taken in deep water in several localities.

Fistularia serrata Cuv. Specimens from Massachusetts Bay are in the museums of the Boston Society of Natural History and the Peabody Academy, Salem; also one from the Western Atlantic in the Colonial Museum at Halifax. Later writers have excluded this species from the fauna of North America, following the lead of Dr. Günther who gives its distribution as exclusively Indo-Pacific. A specimen taken by J. Matthew Jones, Esq., in Bermuda, was identified by Dr. Günther with *F. serrata*. This species must be restored to the faunal relations claimed for it by the earlier American authors, to whom Dr. Günther makes not the slightest reference in his synonymy.

Raia radiata Donovan. This species is well described by Fabricius under the name of *Raia fullonica*. Adults and young have been taken sparingly in Massachusetts Bay, on La Have Bank, in Halifax Harbor, and in Bedford Basin.

Canthorhinus occidentalis (Gthr.) Goode. A specimen of this fish, not before recorded north of Bermuda and Key West, was taken in the summer of 1875 at Linen Island near the entrance to Chesapeake Bay, and presented to the National Museum by Captain John Evans.

Hypeneus maculatus (Bloch) Cuvier. A specimen was taken at Wood's Holl, Mass., July, 1877, by Vinal N. Edwards. The

species occurs in Bermuda, the West Indies, and on the coast of Brazil.

Chilichthys Spengleri (Bloch) Goode. A single individual was taken by Vinal N. Edwards at Wood's Holl, in August, 1877. A West Indian and Madeiran form.

Lactophrys trigonus (Linn.) Poey. Ten or twelve individuals were taken at Wood's Holl, 1877. The species has only once before (in 1833) been taken north of Florida.

ART. LI.—*Volumetric Determinations by Chromic Acid;* by C. W. HINMAN.

IN the early part of the year 1870, while a student at the Institute of Technology, Boston, I endeavored to devise a volumetric assay of lead ores, especially galena. The process first used was briefly this: The finely pulverized ore was decomposed by strong nitric acid and the resulting lead sulphate dissolved by ammonium acetate. The lead solution was then titrated by a standard solution of potassium bichromate, using silver nitrate as an indicator: reddish brown silver chromate being formed as soon as the lead was all precipitated. This process of titration was first given by H. Schwarz, (Dingl. polyt. Journ., clxix, 284). This method worked fairly well except that the reaction at the end was not sufficiently delicate. It has since been recommended by F. Maxwell Lyte (Chem. News, xxx, 293). While searching for a more delicate indicator I found that a drop of a mixture of starch paste, potassium iodide, and some acid would be turned blue by a very small quantity of bichromate; also by suspended lead chromate when the ordinary strong acids were used. But if the mixture was acidified by a solution of one part crystallized citric acid to six of water, lead chromate gave the blue color only after the lapse of some minutes, while bichromate gave it immediately. Quite a number of analyses of pure lead nitrate were made by one of the present professors and myself, using the indicator just described; and the results were quite satisfactory. On trying to use the method in titrating the solution of lead sulphate in ammonium acetate it was found that no blue coloration was produced until there was quite an excess of bichromate present. This was owing to the amount of ammonium salts present, but a number of other substances have the same effect. I then abandoned the process. Th. Rosenbladt (Jahresbericht f. Chemie, 1875) recommends a similar indicator for chromic acid in estimating the quantity of sulphuric acid in drinking water.

During the last few years I have had occasion to make a large number of determinations of the quantity of sulphur in coal gas, and have often wished for some process of determining sulphuric acid less tedious than the ordinary gravimetric one by barium sulphate and more accurate than the volumetric methods in ordinary use; and nearly a year ago I began some experiments to find such a method. Sulphuric acid can be determined by means of chromic acid, and the latter is reduced by quite a number of reagents. I had previously found a delicate test for chromic acid in the acid solution of starch paste and potassium iodide. It remained to be seen if the blue color disappeared as soon as the chromic acid was all reduced. I found that of the ordinary reducing agents only an acid solution of stannous chloride produced this result, even when a large excess of acid was present. I found that a given quantity of potassium bichromate and water always required the same quantity of stannous chloride, but the larger the quantity of water the more stannous chloride was required. This was accounted for on the supposition that the oxygen dissolved in the water was acted on before the chromic acid was all reduced. It was finally found desirable to boil the bichromate solution and cool it out of contact with the air; when this was done the quantity of water present made no difference in the amount of stannous chloride required. The following are the details of the process. The chromate is weighed or measured into a small flask which is then filled with water nearly to the neck. The flask is closed with a stopper through which passes a glass tube, at the end of which is a rubber valve opening outward. The contents of the flask are boiled for some minutes and then cooled; the valve preventing the access of air. A few centimeters of hydrochloric acid are added and then stannous chloride from a glass cock burette until the color is nearly pure green, but taking care to leave a little chromic acid unreduced. A few drops of a mixture of starch paste and potassium iodide added to the contents of the flask produces a dark blue color which is to be removed by the cautious addition of stannous chloride. The exact point is easy to hit as at last the color changes rapidly with a small addition of the chloride. The following determinations were made in this manner, a standard solution of potassium bichromate containing 14·761 grams per liter being used.

$K_2Cr_2O_7$	$SnCl_2$	Ratio.
25 cc. req.	19·26 cc.	·770½
13	10·04	·772
10	7·72	·772
10	7·73	·773
3	2·33	·777
3	2·32	·773
3	2·34	·780

Of course bodies like ferric and cupric salts that are reduced by stannous chloride must be absent and the solution must not be so concentrated that the green of the chromic chloride obscures the iodo-starch blue. Stannous chloride has had the reputation of changing rapidly on standing, but I have found it quite stable, when properly protected from the air, as the following results show:

March 9,	10 cc.	potassium	bichromate	required,	7·74	cc.	stannous	chloride.
" 12,	"	"	"	"	7·72–3	"	"	
April 16,	"	"	"	"	7·73–4	"	"	
May 21,	"	"	"	"	7·74	"	"	

The following determinations can be made by means of chromic acid. The chromates of lead, barium, and bismuth can be accurately precipitated, barium from an ammonical solution, the others from an acetic solution. The determination of lead is given as an example.

Twenty-five cc. of a solution of lead acetate, fifty cc. of which gave 0·5908 gram lead sulphate, were diluted with water and a little acetic acid, heated to boiling in a small beaker and 10 cc. standard bichromate solution added. The precipitate of lead chromate was filtered off after standing a few minutes, washed, and the excess of chromic acid determined in the filtrate. The quantity of stannous chloride required was 0·20 cc.; other experiments gave 0·21, 0.21, 0·20, and 0·20, by calculation from the amount of lead sulphate there should have been required 0·19 cc. being an error of one or two parts in about 750.

If a known quantity of bichromate is added to acid solutions of arsenious or antimonious acids they will be oxidized to arsenic and antimonic acids and the excess of chromic acid can then be determined. Twenty-five cc. of a solution of arsenious acid, containing 5·2675 grams per liter, plus 10 cc. standard bichromate solution, required 1·36, 1·35, 1·33, and 1·35 cc. of stannous chloride. If the arsenious acid had been pure only 1·22 cc. stannous chloride would have been required instead 1·35. In other words the arsenious acid contained about one and four-tenths per cent impurity. The only antimony compound I happened to have at hand was tartar emetic, but tartaric acid in that seemed to interfere with the reaction to a certain extent so that the results were not satisfactory.

Sulphuric acid can be determined as follows: To a slightly acid solution of a sulphate heated to boiling is added a small excess of a solution of barium chromate in hydrochloric acid, barium sulphate is precipitated; then the solution is neutralized with ammonia which precipitates the remaining barium chromate, the precipitates of barium sulphate and chromate are filtered off and the chromic acid determined in the filtrate is equivalent to the sulphuric acid in the original solution.

H_2SO_4 sol.	$SnCl_2$ sol.	Calculated.
3 cc. req.	1·87 cc.	1·85 cc.
5	3·10	3·08
10	6·16	6·15
25	15·38	15·37

Twenty-five cc. of the sulphuric acid solution gave 0·4633 grams barium sulphate.

Perhaps the oxygen in drinking water can be determined by means of the chromic acid method, but my experiments are as yet incomplete.

Having worked for some time with the method of estimating iron by means of stannous chloride, I am convinced that its importance is not yet recognized generally. The following modification seems to simplify the process as given in the last edition of Fresenius' analysis. To the iron solution which has just been decolorized by stannous chloride, add a small pipette full of iodine solution, equivalent to about one-fourth cubic centimeter of stannous chloride, cool, then add a little starch paste and stannous chloride until the color disappears. The equivalent in stannous chloride of the pipette of iodine solution substracted from the whole amount used leaves the quantity required by the iron. By this means the use of a second burette is avoided and less calculation is required.

Office of State Gas Inspection, 32 Hawley street, Boston.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Gases enclosed in Lignite.*—Thomas, in continuation of his researches upon the gases enclosed in coals, has examined with this view the lignites of Bovey Heathfield, Devonshire, and also a specimen of mineral resin, the "retinasphaltum" of Hatchett. A leafy lignite weighing 100 grams, on being kept in a Sprengel vacuum at 50° for twelve days, evolved 56·1 c.c. of gas, consisting of CO_2 87·25, O 0·24, CO 3·59 and N 8·92=100. It was then kept at 100° for eighteen days, and evolved 59·9 c.c. of gas, of which 89·53 was CO_2, 0·33 C_nH_{2n} gases, 5·11 CO and 5·03 N. At a higher temperature, decomposition set in, evolving H_2S and apparently allyl sulphide, mixed with the gaseous products. The gas evolved at 250° contained H_2S 5·85, CO_2 71·13, C_nH_{2n} 1·09, CO 16·20, CH_4 5·46, N 0·27=100. The mineral resin gave no gas at 50°, but at 100° yielded 21·4 c.c. of gas for each 100 grams of resin, consisting of CO_2 88·24, O 0·23, C_nH_{2n} gases 0·47, CO 7·90, N 3·16=100. On further heating the resin began to melt, and decomposition set in at 110° to 112°, the gases collected below 150° consisting of H_2S 0·41, CO_2 78·88, C_nH_{2n} gases

2·67, CO 7·82, CH_4 8·05, C_3H_8 1·86, nitrogen 0·31=100. Compared with the coals proper, lignites show therefore a marked difference in their gaseous contents, approaching most nearly, however, the cannels. But while the greater portion of the gas enclosed in both cannel and lignite consists of CO_2, the former contains the gases and other compounds of the paraffin series and the latter C_nH_{2n} gases as well as oily aromatic bodies and CO. Moreover lignites decompose much easier than coals.—*J. Chem. Soc.*, xxxii, 146, Aug., 1877. G. F. B.

2. *On the Reaction between Insoluble Carbonates and Soluble Oxalates.*—Watson Smith, observing that ammonia was evolved on mixing ammonium oxalate and chalk or marble powder, repeated the experiment with sodium oxalate, and obtained even in the cold a distinctly alkaline reaction. On heating the two substances together and then filtering, the filtrate effervesced on adding hydrochloric acid. This led to a series of experiments to determine the character and extent of this reaction, and to compare it with that of alkali carbonates upon the earthy oxalates. Regarding the possible Na_2CO_3 formed when the decomposition is complete as 100, calcium carbonate treated with sodium oxalate gave 19·83 Na_2CO_3 in the cold and 22·90 when heated; strontium carbonate gave 7·63 in both cases; barium carbonate gave 4·84 and 4·98; and lead carbonate 6·35 and 13·08. Conversely, if 100 represent the possible Na_2CO_3 converted into oxalate, calcium oxalate converted 16·07 in the cold and 52·34 when heated; strontium oxalate 57·24 and 79·96; barium oxalate 73·20 and 87·96; and lead oxalate 81·54 and 90·61. In the cold, calcium carbonate is as much more acted on by sodium oxalate than is barium carbonate, as barium oxalate is by sodium carbonate more than calcium oxalate. In the case of soluble oxalates, the reaction does not appear to be facilitated materially by heat.—*J. Chem. Soc.*, xxxii, 245, Sept., 1877. G. F. B.

3. *On the new Metal Davyum.*—In the month of June last, Sergius Kern succeeded in isolating a new metal belonging to the platinum group, to which he gave the name Davyum, in honor of Sir Humphrey Davy. To prepare it, 600 grams of the platiniferous sand were treated by Bunsen's method for the separation of the platinum, iridium, rhodium, osmium, palladium, ruthenium, iron and copper which it contained. The mother liquors after the separation of the rhodium and the iridium were heated with an excess of chloride and nitrate of ammonium. A dark red precipitate was obtained, which, calcined at a red heat, gave a grayish mass resembling platinum sponge; and this, fused by the oxyhydrogen flame, gave a silver white ingot weighing 0·27 gram, and having a density of 9·385 at 25° C. The metal is hard and malleable at a red heat; it is easily attacked by aqua regia and feebly by boiling sulphuric acid. Potassium hydrate precipitates its solutions yellow. Hydrogen sulphide gives a brown precipitate in solutions of davyum chloride, which changes to black on drying. Potassium sulphocyanide colors this solution red, like

ferric salts, when dilute, and gives a red precipitate when concentrated. In Mendelejeff's classification, the author thinks davyum is the hypothetical element placed between molybdenum and ruthenium.

In a subsequent paper, Kern gives the reactions of the new metal obtained by dissolving his ingot in aqua regia. The yellow hydrate is readily soluble in acids, even in acetic. The nitrate appears as a brown mass, which on calcination gives a black monoxide. Dissolved in potassium cyanide, davyum chloride gives beautiful crystals of a double cyanide. Cyanodavic acid is very unstable. The sulphide is soluble in alkali sulphides, giving sulphosalts. The sulphocyanide crystallizes in large crystals, and becomes black on heating. The chloride is soluble in water, alcohol and ether, and its crystals are not deliquescent. It forms double chlorides easily, that with sodium being almost insoluble in water and alcohol. No second chloride is known. New determinations give the density 9·389. Its atomic weight has not yet been determined, but it is probably between 150 and 154.—*C. R.*, lxxxv, 72, 623, July, Oct., 1877. G. F. B.

4. *Upon Metalacetyl-acetic ethers.*—Conrad has extended the law that negative radicals are found in a molecule in the vicinity of negative groups, by supposing that the energy of the carbon is so raised by the presence of negative radicals, that the hydrogen combined with it may be replaced by positive atoms. In proof of this he shows that a salt obtained by Geuther and supposed by him to have its metal atoms united to the carbon by oxygen, has them in fact united directly to the carbon. In the case of copper-acetyl-acetic ether, prepared by the action of an ammoniacal solution of copper sulphate on acetylacetic ether, the author establishes the formula as $\begin{matrix} CH_3CO\text{-}CH\text{—}Cu\text{—}CH\text{-}COCH_3 \\ | \qquad\qquad\qquad\qquad | \\ COOC_2H_5 \qquad\qquad COOC_2H_5 \end{matrix}$, in which the carbon atoms of the two groups are linked directly by copper. Nickel, cobalt, magnesium, aluminum and mercury compounds were also prepared.—*Liebig's Ann.*, clxxxviii, 269, Aug., 1877. G. F. B.

5. *On Phyllic acid, extracted from leaves.*—Bougarel has succeeded in isolating from the leaves of the cherry-laurel, a new acid to which he gives the name phyllic acid. The leaves are extracted with boiling alcohol, the extract left on distilling off the alcohol, is treated with ether, the solution is clarified with animal charcoal, the ether distilled off, and the amorphous grains dissolved in dilute potash solution and several times crystallized. On re-dissolving and adding an acid, phyllic acid is precipitated as a resinous mass. It is soluble in alcohol, ether, chloroform, CS_2, essential oils and fats, but insoluble in water. Several times precipitated from ether, it forms a fine powder without odor or taste, having a density of 1·014, rotating in alcoholic solution, $\alpha_j = +28$, melting at 170°, and decomposing at 200°. Analysis of the potassium salt fixed the molecular weight at 624; and ultimate analysis, conse-

quently, the formula $C_{72}H_{64}O_{16}$, which the author regards as provisional only. The sodium and ammonium salts are well crystallized. The acid has also been obtained from the leaves of the quince, apple, peach, almond, sycamore, lilac and jaborandi.—*Bull. Soc. Ch.*, II, xxvii, 148, Sept., 1877. G. F. B.

6. *On the Constitution of Euxanthon.*—SALZMANN and WICHELHAUS have experimented to determine the constitution of euxanthon, prepared from euxanthic acid (which exists in the form of magnesium salt in the yellow coloring matter called purree or indian yellow) by solution in concentrated sulphuric acid and precipitation by water. It has the composition $C_{13}H_8O_4$. Its vapor passed over zinc powder in a current of hydrogen gave the product $C_{13}H_8O$. This, oxidized with nitric acid or permanganate gave $C_{13}H_8O_2$; treated with fuming nitric acid, gave a nitro-product $C_{13}H_6(NO_2)_2O_2$; and suspended in water containing bromine formed two bromine derivatives $C_{13}H_2Br_6O$ and $C_{13}HBr_7O$; euxanthon itself heated with acetyl chloride to 100° gave diacetyl-euxanthon, $C_{13}H_6(C_2H_3O)_2O_4$. From these reactions, taken in connection with the fact that Baeyer obtained a hydroquinone-like body on reduction with sodium amalgam, the author regards euxanthon as a carbonein of hydroquinone $CO\begin{matrix}C_6H_3\diagdown\\C_6H_3\diagup\end{matrix}\begin{matrix}OH\\>O\\OH\end{matrix}$, the reduction product with zinc being carbodiphenylene $CO\begin{matrix}C_6H_4\diagdown\\C_6H_4\diagup\end{matrix}>$, giving on oxidation carbodiphenylene oxide $CO\begin{matrix}C_6H_4\diagdown\\C_6H_4\diagup\end{matrix}>O$.—*Ber. Berl. Chem. Ges.*, x, 1397, Oct., 1877. G. F. B.

7. *Density of Vapors.*—One of the most important of the recent additions to chemical methods is that of Victor Meyer for determining the density of the vapor of substances which have a high boiling point. As in the method of Gay-Lussac or in the modification of that method as employed by Hoffman, a given weight of the substance used is converted completely into vapor and the volume of this vapor measured under determinate conditions. An amount of the substance not exceeding seven or eight centigrams but varying naturally with the density of the vapor to be determined is weighed out in a small glass tube of such size and shape that it can easily be passed through the curved neck into a glass bulb holding about twenty-five cubic centimeters. The glass tube at the end of which the bulb is blown is bent into a U shape and cut off so that its open mouth is on a level with a capillary opening on the top of the bulb, and the little apparatus is suspended by a wire holder so that these openings are always uppermost. The glass having been weighed to decigrams and the material introduced, the interior is filled at 100° C. with Wood's fusible alloy which melts at 70° C., the capillary opening at the top of the bulb allowing the air to escape while the melted metal is poured in through the open mouth. As soon as the bulb is filled this capillary opening is closed by a blow-pipe; and as soon as, after exposure in a steam bath, the excess of metal has overflowed, the

apparatus is wiped and again weighed, but as before, only to decigrams. The apparatus is now immersed in the vapor of boiling sulphur, which, according to the experiments of Regnault has a constant temperature of 442·2° when the barometer stands at 723·5 mm.* The substance passes into vapor and a considerable portion of the alloy overflows and the tension of the vapor thus formed is evidently measured by the height of the barometer column at the time, plus the equivalent in mercury of the height of the column of melted metal which fills the neck of the apparatus above the level of the metal in the bulb. The last is easily measured with a millimeter scale if at the instant of lifting the apparatus from the sulphur bath the level of the metal is marked on the bulb, which may be easily done with melted sealing wax, using a heated glass rod as a pen. When now the apparatus has partially cooled and the adhering particles of metal have been removed, it is weighed for the third time and from the three weights we easily ascertain what quantity of metal has overflowed in the sulphur bath. This amount is obviously a measure of the volume of the vapor formed. It is not, however, a direct measure, for the overflow is caused not only by the formation of the vapor, but also by the expansion of the alloy, while, on the other hand, it is diminished by the expansion of the glass. Before, therefore, the data thus obtained could be used in calculating the density of a vapor it was necessary to determine the density of the alloy at the boiling point of sulphur, also the apparent expansion of the alloy in the ordinary German glass when heated from 100° to the same temperature. This Victor Meyer has done, and according to his determinations the apparent expansion of the alloy was, on the average, 0·036, and at 444° one gram had the volume of 0·1092 c. c., so that its density was about two-thirds of that of mercury. From these values he deduces the following formula for the calculation of the vapor density from such observations as we have described:

$$\text{Density (referred to air as unity)} = \frac{w\ 14146000\dagger}{(W - 0{\cdot}036\ W')(H + \frac{2}{3}h)};$$

* This is the mean height of the barometer at Zurich where Meyer's determinations were made. At the mean level of the sea with the mean height 760 mm. the boiling point is more nearly 447·7°.

† At the sea level when the barometer stands at 760 mm. this constant becomes 14216000. Either value is easily deduced.

The amount of substance taken gives at 444·2° a definite volume of vapor at a measured tension. Let that volume in cubic centimeters be represented by v and the tension in millimeters by H′. The density of the vapor is equal to its weight divided by the weight of the same volume of air at the same temperature and tension, or $\delta = \frac{w}{w'}$ and as is well known,

$$w' = 0{\cdot}001293\ \frac{1}{(v1 + 0{\cdot}003665{\cdot}444°{\cdot}2)} - \frac{H'}{760}.$$

But in the process we are considering the volume of the vapor is evidently equal to the volume of the overflow at 444·2° less that of the overflow which would have resulted from the expansion of the metal and glass alone, or $V = 0{\cdot}1092\ (W - 0{\cdot}036\ W')$ and as we have seen, $H' = H + \frac{2}{3}h$. Making now the substitutions and combining the numerical values we obtain the expression given above.

here w is the weight of the substance used, W′ the weight of alloy which filled the bulb at 100°, and W the weight which overflowed in the sulphur bath; also H the height of the barometer and h the difference of level of the alloy in the bulb and neck of the apparatus at the moment it was withdrawn from the bath.

Wood's fusible alloy is exceedingly well adapted to the use to which it has been so beautifully applied by Victor Meyer. As prepared and sold by Dr. Schuchardt of Görlitz it appears to have a very constant composition and equally constant physical qualities. Moreover, it is but slightly acted on by boiling sulphur and can readily be recovered from the sulphur bath into which it overflows. It can then be easily cleaned and used over again repeatedly. But for these and other details we would refer to the very full description of the process which has recently appeared in Fresenius' Zeitschrift für Analytische Chemie, xvi, 482. Of course the method has a limited application and can not be used with any substance which would act chemically upon the alloy. Still it has already very considerably extended our knowledge of the vapor densities of the less volatile organic products, and for such substances it is both more easy of application and more accurate than the only comparable method, that of Dumas as modified by Deville and Troost. We add two examples for illustrations.

Anthrachinon.

Substance used	w	= 0·0652 grm.
Metal used	W′	= 264·4 "
" which overflowed	W	= 179·6 "
Barometer height	H	= 728·5 mm.
Difference of level	h	= 33· "
Resulting density		7·22
Theory for $C_{14}H_8O_2$		7·19
Found by Gräbe with the process of Deville and Troost		7·35

Paradibrombenzol.

Substance used	w	= 0·0772 grm.
Metal used	W′	= 261·5 "
" which overflowed	W	= 187·4 "
Barometer height	H	= 728·5 mm.
Difference of level		38 "
Resulting density		8·14
Theory for $C_6H_4Br_2$		8·15

J. P. C., JR.

8. *New Results in Physics.*—(1.) A. F. BERGGREN concludes that the chlorides of the alkalies and alkaline earths possess greater electrical conducting power than the soluble sulphates of the same bases.—*Ann. der Physik und Chemie*, new series, vol. i, p. 499.

(2.) SILOW has undertaken an investigation of weak magnetic substances. His method consists in observing the deviation of an astatic system of needles, produced by appending to it a cylin-

drical vessel containing the magnetic substance under consideration. He discusses the method by the aid of the theory of potentials and obtains for an aqueous solution of chloride of iron of density 1·475 a magnetizing constant of $K = 0{\cdot}0000815$.—*Ib.*, p. 481.

(3.) HANKEL discusses the results of previous experiments upon the electrical effect of light rays upon metal plates, immersed in fluids, and adds some experiments of his own which show that the difference of potential of certain metal plates immersed in fluids is sensibly altered by light; and that in certain cases this effect is opposite to that caused by the heat rays.—*Ib.*, p. 402.

(4.) CLAUSIUS shows that if there are a number of conducting bodies C_1, C_2, C_3, etc. which influence each other and if these bodies are first charged with the quantities of electricities Q_1, Q_2, Q_3 etc. giving the potentials V_1, V_2, V_3 etc., and afterwards charged with the quantities $\mathfrak{Q}_1$, $\mathfrak{Q}_2$, $\mathfrak{Q}_3$; with the potentials $\mathfrak{V}_1$, $\mathfrak{V}_2$, $\mathfrak{V}_3$; the equation $\Sigma V\mathfrak{Q} = \Sigma\mathfrak{V}Q$ results.—*Ib.*, p. 493.

(5.) HERMAN HERWIG collects the facts in regard to the different mechanical actions of positive and negative electrical poles; joins to these some observations of his own in regard to the behavior of flames placed between their poles, and discusses the generality of these phenomena together with their bearing upon the two-fluid theory of electricity.—*Ib.*, p. 516.

(6.) According to an investigation of W. von MUNCHHAUSEN carried on in the laboratory of A. Wullner, the specific heat of water at $t°$ is represented by the expression $K = 1 + 0{\cdot}000302t$.—*Ib.*, p. 592. J. T.

II. GEOLOGY AND MINERALOGY.

1. *China*, by FERDINAND FREIHERRN VON RICHTHOFEN. 1st vol. Introductory Part. 758 pp. roy. 8vo, with 11 charts (several colored), and 29 wood cuts. Berlin, 1877.*—Baron von Richthofen left Europe on his first visit to China in 1860, under the auspices of the Prussian Government. Only a few prominent points in China were visited, the interior of the country not being then accessible, owing to the Taiping rebellion. He also went to Siam, Formosa, the Philippines, Celebes and Java. Japan was not at the time open to foreigners.

The year 1867 and part of 1868 were spent in California, in connection with the Geological Survey of that State under J. D. Whitney; and a volume treating learnedly of the Natural System of volcanic rocks, and describing those of Western North America was one result of his labors.

In July, 1868, he left for a second visit to China. He was there the larger part of four years, and made seven long journeys over the country, and among the islands and peninsulas of the coast. He visited many of the Provinces, reaching, at his farthest point

* *China.* Ergebnisse eigener Reisen und darauf gegründeter Studien; von FERDINAND FREIHERRN VON RICHTHOFEN. Erster Band. Einleitender Theil. Berlin, 1877. (Verlag von Dietrich Reimer.)

west, the center of the Province of Sz-tschwan, over 900 miles west of Shanghai, and to the north, the borders of Mongolia, northwest of Pekin. During a portion of the years 1870, 1871 (from August, 1870, to the spring of 1871), he was in Japan.

The work, of which the 1st volume, out of the four to be published, has recently been issued, will embrace the results of his observations and studies with reference to the topography of China, its geography, climate, density of population in different parts of its history, its productions and their mercantile importance, its geology, paleontology, etc. Besides the account of China, the work will contain a sketch of the author's observations also in Japan, Formosa, Manilla, Java and Siam; and, in conclusion, a discussion of some problems connected with the earth's general features and history, as illustrated by the special facts observed.

The fourth volume, on the Paleontology, will be prepared by prominent specialists, among them, Dr. Kayser of Berlin, Prof. Schenk of Leipzic and Dr. Schwager of Munich. There will also be an atlas of forty-four charts, besides numerous cuts and maps in the text. The atlas will contain twenty-eight special charts on the scale of 1:750,000; a general chart of China, on that of 1:3,000,000; and other charts to illustrate the geology, geography of products, density and movements of population, etc., in China; also, a general chart and several special charts of Japan. The volume issued is princely in its style of publication; and it manifests, besides, that the work will be thorough in its discussion of the subjects taken up.

The first volume commences with a survey of the general topography of China and Central Asia. It next treats of the löss-formation of Northern China—its features, structure and origin, and its relations to the salt steppes of Central Asia and the löss-deposits of other countries. The mountain-systems of Central Asia are then described, and with this subject Part I closes. Part II consists of a history of geographical knowledge with regard to China, and treats of ancient Chinese geographies and charts, Chinese geographical learning, and the development, during the different periods of Chinese history, of the intercourse of the people with the people of Southern and Western Asia, and, after the arrival of the Portuguese, in 1817, with the nations of Europe.

The account of the *löss-formation of Northern China* is of special interest, because of its wide distribution and its connection with the social condition and welfare of the people. Baron von Richthofen observes that west of the alluvial plain of the sea-border —which plain in the vicinity of Pekin extends 175 English miles west from the Petschili gulf—there is a terrace of löss thirty to eighty meters in height. Continuing west, there is, next, a mountainous region on the east border of the Province of Shansi, and then succeeds a plateau largely covered with löss, which is 600 to 1,000 meters above the sea-level. Again, farther west, after passing a mountain range, there is a second plateau, 1,500 to 1,800

meters above the sea-level, which is covered in great part with löss. The river Fönn-ho (a stream flowing southward into the Hoang-ho, through the center of the Province of Shansi), occupies a deep channel cut through it along its western border. West of this plateau there is another mountainous region, in which flows north and south, for 300 miles, the Hoang-ho or Yellow River. Beyond, through the Provinces of Shensi and Kansu, the löss is widely spread; and, on the authority of the missionaries and the Chinese, it continues in the valleys to the most western sources of the affluents of the Hoang-ho, over 900 miles from the coast. The löss spreads northward along the plains or valleys into Mongolia. Southward, it occupies basins in the broad valley of the Wei, the largest tributary of the Hoang-ho; and it also occurs in the valley of the Han. It is found also farther east over parts of the low near Nanking, Tung-ting Lake, and Po-yang Lake, which are its lands of Honan and Shantung. South of Honan it exists in isolated areas along parts of the valley of the Yang-tsze River, as extreme southern positions. Its greatest areas are in the region of the Hoang-ho and its tributaries, in some portions of which it has a thickness of several hundred feet—even 2,000 to 2,500, according to Baron von Richthofen.

The material of the löss, like that along the Rhine, is a brownish-yellow earth (whence the name "Yellow River," given to the Hoang-ho), very porous, exceedingly fine in grain, and friable when dry; and affording on chemical analysis, more or less carbonate of lime. It often contains, at different levels, calcareous concretions (Löss-männchen); and also in some places the shells of land-snails and bones of terrestrial mammals, but never, according to the author, shells of fresh-water snails. Vegetable remains also occur in it. From top to bottom it is penetrated by very small tubular passages, which are like those that are now in many places left by the rootlets of grasses and other small plants, after their decay; and these are set down as evidence that the whole mass of the löss has been successively penetrated by the rootlets of growing plants. The löss deposits have very generally, as on the Rhine, a vertical cleavage structure leading to its becoming eroded vertically, and is without the thin horizontal lamination or planes of bedding of ordinary alluvium. There are often, however, at intervals usually of more than fifty feet (but varying from a few feet to more than a hundred), horizontal divisional planes which are usually connected with planes of concretions. In consequence of these structural peculiarities, the löss fronts the valleys with high vertical walls, in which are occasional horizontal terrace-like shelves. It becomes reduced by intersecting streams or streamlets, and the rills from the heavy rains, to regions of deep and narrow labyrinthine passage-ways, groups of lofty obelisks, castles, clustered towers. Instructive views of its scenery are given in the volume.

Baron von Richthofen discusses the theories as to the origin of the löss, and adopts that which he had advocated in his memoirs

on the Provinces of Honan and Shansi, published at Shanghai in 1870. He objects, with reason, to the theory of marine submergence, advocated by T. W. Kingsmill, Esq., in the Quarterly Journal of the Geological Society for 1871 (p. 376,) on the ground that the shells, bones and vegetation are all terrestrial; that there are no marine relics of any kind in the deposits; and states that it would require an oscillation of level of several thousand feet, which would give a chance for the introduction over the area of China, within comparatively recent times, of all kinds of marine life. He rejects also the view that the löss is of freshwater origin deposited from the waters of vast lakes that formerly covered a large part of the country—the opinion brought out by Raphael Pumpelly in his valuable "Geological Researches in China, Mongolia and Japan," published in 1866;* urging that the shells are not transported shells, but instead occur where they were left by their animals; that there are no freshwater species; that the indications of vegetation (mentioned above) are so extensively distributed through the löss, that the plants must have grown abundantly over its surface as the accumulation went forward instead of being a deposit by transporting waters; that the bones of mammals indicate also that they have not been transported. He says also that there is no evidence of glacial origin, no moraines or other marks of glaciers having been observed in any part of the country.

Baron von Richthofen holds that the löss formation is a subaerial accumulation, due to the drifting action of the winds; to transportation by rivulets from the hills immediately adjoining each löss basin; and to the mineral material left over the basin by the growing grasses and other plants. The first and the last of these causes are made the most effectual. The degradation of the rocks of the neighboring hills by decomposition and alternate changes of temperature, produces the loose grains for transportation. The plants covering the great plains served to stop the wind-drifted earth, and so keep the accumulation ever in progress. He observes that the true löss is made over a dry surface and he calls it *land-löss*. But the löss basins have generally had a lake at center; and about the lake the deposit is thin-laminated or stratified; and

* Mr. Pumpelly's Memoir was published in a quarto of 144 pages, with maps, by the Smithsonian Institution, as No. 202 of the Smithsonian Contributions to Knowledge, Washington, D. C., October, 1866. The author visited the region northwest of Pekin on the borders of Mongolia. His descriptions of the features of the löss regions are like those of von Richthofen. He says, after alluding to its vertical cleavage: "The country is often cut up by gullies thirty to seventy feet deep, and from ten to twenty feet wide, with vertical walls. In these channels wagon-roads run for many miles without rising to the plain. In the valley between the Kwantung (pu) and the Yangkau defile, I crossed a gully forty or fifty feet deep and not more than four feet wide, having the same breadth all the way down. and following, with these dimensions, a tortuous course for more than a mile." "Wherever a cliff of this deposit presents itself, the beginning of this action is visible. The surface drainage of a small neighboring area of the plain being concentrated toward one point on the edge of the cliff, cuts, in its fall, a channel from top to bottom, and this with each succeeding rain works its way backward toward the mountain. As the erosion progresses, the sides of the gullies offer new starting points for tributary ravines."

this he calls *lake-löss.* The lakes had formerly greater width than now; and in the valley of the Wei where the true löss is extensive, he has seen it overlying the laminated lake-löss. About the dried-up basins, under the present dry climate, salt efflorescences are common.

From all the facts he concludes that the löss-basins were originally sites of salt lakes; that the land had less height in the interior to the northward than now, as shown by the succession of löss basins going west, and that the basins had consequently very great extent; that the climate was so dry that the evaporation exceeded the fall of water, and consequently the streams were very feeble, or dried up, and that this was another occasion for great undrained basins; that the true löss was formed about the dry borders of the basins by the methods above mentioned, and gradually spread inward covering the lake-löss as the water of the basin diminished, so giving the upper surface of the deposit a slight pitch inward, which feature he states (as also Pumpelly) is common; that the condition of Northern China, at the time, was much like the present state of the salt-steppes of Central Asia; and that the löss-making era was brought to an end by a change of climate in which great rains changed the rivers to floods, which led to their cutting channels through the basins and opening up the present system of drainage. Thus the Hoang-ho came into its modern existence. The reference to a less height formerly over the interior than now would seem to imply that this drainage result was promoted also by an elevation to the present level. The löss where it adjoins the hills often contains alternating beds of pebbles and earth; and this is attributed to rivulets from these hills. The salt-steppes of Central Asia are particularly described in order to illustrate the views advanced.

Mr. T. W. Kingsmill's article, referred to above, was written as a criticism of Baron von Richthofen's views; and it is of interest here to have his arguments. The most important are these: that the disintegration going on over the hills is a very inadequate source of material for such great and thick deposits, and the winds an insufficient means of transportation; that the plants could furnish to the mineral accumulations only what they took from it, and hence would add nothing; that the löss is so easy of removal that, if terrestrial in origin, it would have been more or less carried off, and hence so thick accumulations could not have been made. Mr. Pumpelly's memoir appeared in advance of Baron von Richthofen's. He argues (from facts observed northwest of Pekin and about Kalgan) for the freshwater and lacustrine origin of the löss from the presence of shells in the deposits (at Té Hai); from the uniform constitution and fineness of the löss, this "proving that it has not come from what were the neighboring shores, but that it was brought into the lakes by one or more large rivers, which must have drained an area of great extent." J. D. D.

2. *International Geological Congress.* — The number of this Journal for December of 1876 contains the announcement of the

appointment of a Committee, by the American Association for the Advancement of Science, to take action with reference to holding an International Geological Congress at Paris, during the Paris Exposition of 1878; and also the resolution adopted, and a statement of the objects to be accomplished; the facts being derived from a Circular issued by the Committee, of which Prof. James Hall is Chairman.

At the recent meeting of the Association, at Nashville, a report on the subject was presented by the Secretary of the Committee, Dr. T. Sterry Hunt. According to it, the circular was sent to learned societies over the world, and has everywhere called forth gratifying responses. The Geological Society of France has expressed its hearty coöperation; and English, Russian, Swedish, Norwegian, Austrian, Spanish and Italian geological societies and geologists have given their approbation, and assurances that they will further the objects of the Congress. Prof. Capellini has, in this connection, called attention to the fact that in 1874 he laid the project of a similar International Geological Congress, to be held in Italy, before the Italian Minister of Agriculture, Industry and Commerce. Germany has declined to take any part in the French International Exhibition, but this may not prevent her geologists from joining in the proposed Congress. The precise date of the Congress has not yet been fixed. The Secretary of the Committee is now in correspondence with the Secretary of the Geological Society of France upon this point, and believes that a time convenient to all will be agreed upon.

The Report also embodied a resolution of the Standing Committee of the Association recommending that the Presidents, for the time being, of the Geological Societies of France, London, Edinburgh, Dublin, Berlin, Belgium, Italy, Spain, Portugal, and the Imperial Geological Institute of Vienna, be invited to form part of the Commission.

After the presentation of the report to the American Association, the Secretary received official notice that the Geological Society of France, had, in coöperation with the above plan, appointed in Paris a local committee of organization for the proposed Congress, constituted as follows: Hébert, President; Tournouer and Albert Gaudry, Vice-presidents; Bioche, Treasurer; Jannetaz, Secretary-general; Delaire, Sauvage, Brocchi and Vélain, Secretaries; with the following: Belgrand Bureau, de Chancourtois, G. Cotteau, Damour, Daubrée, Delafosse, Delesse, Descloizeaux, Desnoyers, Fouqué, Gervais, Gruner, De Lapparent, Mallard, Milne-Edwards, Pellat, Marquis de Roys and L. Vaillant, members of the Committee.

A circular issued by this Committee, bearing date July 31, invites all those interested in geological, mineralogical and paleontological studies, to take part in the approaching Congress, and to subscribe the sum of *twelve francs* each, which will give a card of admission to the Congress, and right to all the publications

thereof. All those who intend to be present are at the same time invited to send, as soon as possible, a list of the questions which seem to them worthy of general discussion, as well as of the communications which they intend to make touching these questions. They are also invited to indicate what time appears to them most convenient for the meeting of the Congress.

As regards an International Geological Exhibition, the Paris Committee of organization state that the difficulty of finding a suitable locality seems to them an obstacle in the way of realizing this part of the programme. They hope however that there will be many special collections sent, and beg the exhibitors of such to give the committee due notice of these, in order that a special catalogue of them may be prepared.

The circular issued by the Committee of the American Association did not contemplate, as Dr. Hunt states, the holding of an International Geological Exhibition apart from the Universal Exhibition, but, in the language of that circular, *the making as complete as possible the geological department* of the Universal Exhibition. It is certain that, as at all previous similar exhibitions, the different nations will contribute more or less of geological material; and it was conceived that such collections, extended and systematized in accordance with the plan set forth in the circular, would, while forming a part of the Universal Exhibition, without farther cost meet all the requirements of an International Geological Exhibition. To the accomplishment of this end it will only be necessary for the exhibitors of all nations to send a list of their geological contributions to the local Committee of organization at Paris.

All correspondence relating to the Congress should be addressed to Dr. Jannetaz, Sécretaire-général, Rue des Grands Augustins, 7, Paris, France, and all moneys sent to Dr. Bioche at the same address.

3. *Palæontology of New York. Illustrations of Devonian Fossils: Gasteropoda, Pteropoda, Cephalopoda, Crustacea and Corals, of the Upper Helderberg, Hamilton and Chemung Groups;* by JAMES HALL. Over 140 quarto plates. Albany, 1876. Published in advance of the Palæontology of New York, by authority of the Legislature of the State of New York.—Volume IV of Professor Hall's great work on the Paleontology of New York was published in 1867, and contained descriptions and figures of the fossil Brachiopods of the Upper Helderberg, Hamilton, Portage and Chemung groups, illustrated by about seventy plates. Since its publication, as the Preface to this new volume states, the drawings for the plates of the remaining part of the Devonian fossils have been going forward, while, through duties connected with the care of the Museum, in connection with impaired health, the descriptions still remain incomplete. In 1875, *eighty* plates of the Lamellibranchs had been drawn and lithographed, and the drawings of the greater part of the Gasteropods, Pteropods, Cephalopods and Crustacea, now issued in this new volume, had

been finished, while those of the Corals were in progress. During that year the Legislature of the State authorized the publication, by the albertype process, of a hundred copies of each of one hundred of the plates, and, the following year, of thirty additional plates. Through this means the new volume of plates, with the explanatory pages of text, has been issued. All the plates it contains were photographed from excellent original drawings, excepting part of those of the Corals which are direct from the specimens. The most of the drawings were made under the supervision of Mr. R. P. Whitfield, and many of those of the Gasteropoda and Cephalopoda with his aid.

The plates form a beautiful volume, and, with the explanations accompanying each, they constitute a work which will be of great immediate service to the science even without the promised volume of text. The albertypes, by E. Bierstadt, are admirable, and those direct from the specimens of corals are unusually fine. In preparing the explanations of the plates of Corals, Dr. Rominger, whose labors and publications in connection with the Michigan Geolological Survey have made him an authority in that department, was conferred with, in order to avoid any duplication of species.

Professor Hall states that to complete the Devonian Cephalopoda, the number of plates—here forty—will have to be doubled, the plates of the Crustacea will need some additions, and those of the Corals, here over forty, will have to be greatly increased in number. Prof. Hall's labors have been of vast service to American Paleontology, and of great honor to the State under whose auspices his Reports have been published, and it is to be hoped that they will not be brought to a close before every fossil species of the New York rocks has been illustrated and described.

4. *Twenty-eighth Annual Report of the New York State Museum of Natural History, by the Regents of the University of the State of New York.* 100 pages, 8vo, with 34 plates. Transmitted to the Legislature, March 30, 1875. Albany, 1875.—This Report, whose contents are mentioned on page 432, is one of special paleontological value. The chief article is by Prof. Hall, and consists of plates and their explanations illustrating "the fauna of the Niagara Group in Central Indiana." The number of plates is thirty-two. The figures include species of fossil Sponges, Corals, Crinoids, Bryozoans, Brachiopods, Gasteropods and Trilobites, many among them new.

The first two plates illustrate new species of Fungi, described by the State Botanist, C. H. Peck. The new Trenton fossils described by C. D. Walcott are of the genera *Conularia*, *Conchopeltis* (new patelliform shell), *Bathyurus* and *Asaphus*.

5. *Notes on some new sections of Trilobites from the Trenton Limestone and descriptions of new species of fossils*, by C. D. Walcott. 22 pp. 8vo, with one plate. Published in advance of the Rep. N. Y. State Museum, Sept. 20, 1877.—In this paper Mr. Walcott gives an account of the discovery of articulated append-

ages connected with the mouth of Trilobites, derived from sections of Trenton specimens of *Calymene senaria*, *Ceraurus pleurexanthemus* and *Acidaspis Trentonensis*. Only two sections are figured and their precise position across the head is not stated. More sections are needed before the facts observed can be satisfactorily interpreted.

Mr. Walcott has also observed in sections of the body of a *Ceraurus pleurexanthemus* what he regards as remains of the ova of the animal, similar to those described by Barrande as occurring in *Barrandia crassa*. The space between the dorsal shell and the ventral membrane, and the cavity of the head in part, were found to be filled with the ovoidal bodies, over 200 of which were counted in one section. The diameters were one-quarter and one-half of a millimeter. The eggs of Crustaceans are so destructible that the question naturally arises whether the ovoidal bodies are not of concretionary origin.

6. *Large Bowlders in New Hampshire.*—One of the largest of bowlders has been recently found by Governor Prescott upon the land of E. H. Chase in the west edge of Nottingham, New Hampshire, at the base of Pawtuccaway Mountain. It measures 62 feet long, 40 wide and is at least 50 feet high. The cubic contents are about 70,000 feet, giving for the weight nearly 6,000 tons. Close by this are two others, each including nearly 50,000 cubic feet; and within the distance of one-fourth of a mile are nine more of about the same size.

The largest bowlder in Vermont is called the Green Mountain Giant, lying on a hill in Whitingham; it contains 40,000 cubic feet.—*Daily Monitor, Concord, New Hampshire*, Oct. 15.

7. *Application of Organic Acids to the Examination of Minerals;* by H. Carrington Bolton, Ph.D. 36 pp. 8vo, with one plate. New York Acad. Sci., i, 1877.—Professor Bolton presents in this memoir the results of a long investigation with regard to the action of citric, tartaric, and oxalic acids on minerals, and their use in the determination of species; and also of a few trials with malic, formic, acetic, benzoic, pyrogallic, and picric acids. The minerals were subjected to the acids in powder, the solid acids having been made into saturated solutions.

From a table in the concluding part of the memoir, we take the following reactions of citric acid. CO_2 is given off when the cold acid acts on the mineral carbonates, excepting magnesite and siderite which require heat. CO_2 is also given off, when acting with the hot acid on wad, hausmannite, manganite, and psilomelane. H_2S is liberated when acting with the cold acid on stibnite, galenite, sphalerite, pyrrhotite, and, with the hot acid on bornite and bournonite as well as the preceding. A jelly is formed when the hot acid acts on willemite, datolite, pectolite, calamine, natrolite; and non-gelatinous silica, when the same acts on wollastonite, chrysolite, chondrodite, chrysocolla, prehnite, apophyllite, rhodonite, analcite, chabazite, stilbite, serpentine, retinalite, deweylite. The following minerals are decomposed by boiling

with citric acid and KNO_3: argentite, chalcocite, pyrite, marcasite, niccolite, smaltite, chalcopyrite, ullmannite, arsenopyrite, tetrahedrite, uraninite, and also the species above enumerated as decomposed with the H_2S. The following are decomposed by boiling with citric acid and NH_4Fl: olivine, wernerite, orthoclase, albite, labradorite, augite, diopside, hornblende, cyanite, talc, spodumene, almandine garnet, epidote, and also the above-enumerated species which yield silica.

Professor Bolton remarks that solid citric (or tartaric) acid is far more convenient than hydrochloric for the traveling mineralogist; and also that potassium nitrite, KNO_2, should be added to the usual list of blowpipe reagents; for it yields with citric acid, nitric acid, and it affords a convenient means of carrying this reagent. We refer to the memoir for special details with reference to the several mineral species studied by Professor Bolton.

8. *Note on Uranium minerals in North Carolina;* by W. C. KERR, State Geologist. (Communicated.)—Besides the samarskite of the Wiseman Mica Mine in Mitchell County, with the associated hatchettolite of Dr. Smith, the minute crystals of microlite found in several mines, and some stains and incrustations of uranium compounds, a new locality, the Flat Rock mine, recently visited, has yielded the following, in immediate association, viz: *Uraninite*, *Gummite*, *Uraconite*, and, as incrustations on the outside of the latter, and of the fragments of rock adjacent, *Torbernite* and *Autunite*. These minerals occur only in one part of the mica-bearing portion of a very large granite vein, and are found in irregular nodules and rounded masses, some with a nucleus of uraninite of one-half to three-fourth inch, enveloped with a heavy layer of gummite, outside of which is a pale yellow earthy coating from an eighth to a fourth of an inch thick, which is uranochre, or uraconite. One lump, the largest, weighs just a pound, and in all I obtained between three and four pounds. The quantity of pitchblende remaining unaltered is very small and by far the greater part of the mass of the nodules, probably nine-tenths, is gummite; and the smaller ones are nearly or entirely changed to uraconite.

I have recently obtained specimens, one pound in weight, of samarskite from a new locality, viz: Grassy Creek Mine, in Mitchell County. Previously this mineral had been found chiefly, I believe only, at the Wiseman Mine.

A notable fact in connection with the occurrence of these uranium compounds is their association with a characteristic pinkish feldspar, which suggests the inquiry whether there may not be another mineral of this group not yet determined; and this is rendered the more probable by the presence, in the Wiseman Mine at least, of a thin earthy coating on the cleavage surface of the feldspar of a pronounced pinkish color. Professor Julien has some of this in hand for determination, as soon as he can isolate enough for that purpose.

III. Botany and Zoology.

1. *The Wild Flowers of America;* illustrated by Isaac Sprague. Text by George L. Goodale, M.D., Assistant Professor of Vegetable Physiology and Instructor in Botany in Harvard University. Part II. Boston, H. O. Houghton & Co.—No color-printing of flowers in this country had at all equalled that of the first part of this beautiful work. Yet the long interval between its appearance and that of the present fasciculus need not be regretted, since it has enabled the lithographers to do still better justice to Mr. Sprague's drawings, and to the beautiful subjects of them. Those unacquainted with the perfection to which the art has been brought will find it hard to believe that these plates have not been painted by the hand, and by no ordinary hand. The text is well done, especially where, as in the Iris or Blue Flag, and the Arrow-leaved Violet, the subject allowed of interesting treatment. The flowers not having been selected for other than pictorial representation, it sometimes happens that there is little to say about them. But when the nomenclature has been brought up to date so closely as to adopt the genus *Steironema*, it might have been mentioned that the cogent reason for the rehabilitation of Rafinesque's genus was not the sterile filaments, which were known from the first and suggested the name, but the involution of the petals in the bud around the filaments, separately enwrapping each, which was a new discovery. In the letter-press accompanying the very pretty plate of *Viola sagittata* (which is well set off with a tuft of sedge behind it), the method of the discharge of the seeds is clearly explained, and the nearly similar mode in *Hamamelis* is incidentally alluded to as if it were a recent discovery of the persons mentioned. Far earlier dates are referred to in this Journal for Feb., 1873, with a reference to the amusing muddle of the subject into which an English scientific periodical was led. Eastern flowers have served hitherto; but in the present fasciculus the ultra-Mississippian *Rudbeckia* (*Lepachys*) *columnaris* figures, and to great advantage, especially the two-colored variety. The velvety red-brown bases of the drooping yellow rays is admirably rendered. A. G.

2. *Cleistogamy in Impatiens.*—When M. A. Loche, a year ago, read a paper before the Botanical Society of France (printed in its Bulletin, xxiii, 367), in which he described the production of fruit and seeds in *Impatiens Nolitangere*, apparently without participation of the male sex, and when two learned botanists present suggested that this might be a case of clandestine flowering or close-fertilizing in the bud, as in *Lamium* and in *Viola*, it is remarkable that no one called attention to the fact that this case of Impatiens was described and properly explained by Adrien de Jussieu thirty-three years ago, in a classical work, and the observation credited to Weddell, the excellent botanist whom we have since lost. A. G.

3. *Catalogus Plantarum in Nova Cæsarea Repertarum.*—This is the title on the cover. The title page, all English, is "Catalogue of Plants growing without cultivation in the State of New Jersey, with a specific description of all the species of Violet found therein, Directions for Collecting, Drying, Labeling and Preserving Botanical Specimens, and a description of suitable apparatus therefor; with suggestions to Teachers prosecuting the study of Botany; to which is added Directions for commencing the study of Botany; also a Directory of living Botanists of North America and the West Indies. By Oliver R. Willis, Ph.D., Instructor of Natural Science in the Alexander Institute. Revised and enlarged edition, (A. S. Barnes & Co.: New York, &c." 8vo, pp. 88.) This full title leaves no need and little room for any particular account of this compendious volume. It lacks only a date, which we may put at 1877, and it has an Index. The preface to the first edition bears the date 1874. We gave a notice of the original edition at the time; the present edition is much enlarged and improved. The author, supposing that his publication "will fall into the hands of men who can form a just estimate of the difficulties and labor incident to the preparation of a work like this," adds that, "consequently I expect to be judged with lenity and criticised with charity." We see no good reason for disappointing his expectations. We will add—since the title page does not mention it—that, while the catalogue stops with the *Lycopodiacea*, it is supplemented by one of marine Algæ, by Samuel Ashmead, and that there is a monograph of the forms or varieties of the fruit of one of the States' staple products, the cranberry. New Jersey has a rich flora, as is well known. This catalogue enumerates 1,603 species of Phænogamous plants, and states that there are fifty-seven first class and thirty-seven second class trees. But this includes introduced species. A. G.

4. Sir Joseph Dalton Hooker reached his home at Kew on the 19th of October, after an unusually long voyage of almost a fortnight. In his rapid reconnoissance of the botanical features of the United States he traveled over between nine and ten thousand miles of American territory, ascended some of the highest mountains, and botanized with a vigor and industry which he could hardly have excelled in his youthful days. The time—all too short—was almost wholly given to the wide regions between the Mississippi and the Pacific, for which, through the connection with Dr. Hayden's Survey, and with his personal assistance and companionship (as well as that of a fellow botanist of long experience), unusual facilities were afforded. He promises to renew his visit as soon as possible, and then to endeavor to see something of the Atlantic States (its institutions as well as its natural productions), and also of New Mexico, Arizona and Southern California, which are now becoming readily and promptly accessible to the rapid-moving traveler.

Nature for October 25 contains an excellent steel portrait of Sir Joseph Hooker as one of the series of Scientific Worthies; the

accompanying biographical notice is by his companion in American travel, Professor Gray, but was written in May, and was in type before Sir Joseph reached this country. The same number of Nature contains two pages of Notes on the Botany of the Rocky Mountains, a brief sketch, drawn up by him on the homeward voyage. A. G.

5. GEORGE HADLEY, M.D., Professor of Chemistry in the University of Buffalo, died, at Buffalo, N. Y., Oct. 16, in the 63d year of his age. So passes to his rest the last and the oldest of the three gifted sons of gifted and most excellent parents. The subject of this notice, called to a less conspicuous position, did not attain the eminence of his brother James, but rather followed in the footsteps of his father, Professor James Hadley, the first Professor of Chemistry in the Medical College of the Western District, N. Y., at Fairfield, then at Geneva, and lastly at Buffalo, where his son succeeded him. The father and the son were singularly alike, model teachers and model men, truthful to the core and loveable exceedingly, modest and quiet to a degree that masked from the world their ability and their learning: but these traits could not be hidden from those who in two generations came under their influence and shared their abiding friendship. From the father the writer of these lines received, when a youth of sixteen, his first help as a student of botany, and later his first encouragement in essaying a scientific career. He would lay this tribute to the memory of both father and son upon the tomb now opened to receive the mortal remains of the latter. A. G.

6. JOHN DARBY, who graduated in 1831 at Williams College, was born in North Adams, Mass., Sept. 27, 1804. His life was devoted with remarkable steadfastness to teaching in the departments of Mathematics, Chemistry and Natural History, for which he had a great fondness. For some years after his graduation he taught these subjects at the Barhamville Female Institute in Columbia, S. C. He subsequently taught the same subjects for many years in the Georgia Female College at Macon. He filled the chair of Mathematics for one year in Williams College, his alma mater. From this chair Professor Darby went to Auburn in Alabama as Professor of Chemistry and Natural History in the East Alabama College, where he continued until his death in August, 1877.

Professor Darby's scientific work outside the time occupied in teaching—to which he ever gave a most conscientious and willing devotion—was chiefly in botany, of which science he was an enthusiastic student. In 1855 he published his "Botany of the Southern States," in two parts: I. Structural and Physiological Botany and Vegetable Products. II. Descriptions of Southern Plants, arranged on the natural system, preceded by a Linnæan and Dichotomous Analysis. In a critical notice of Professor Darby's work, Dr. Gray (this Journal, vol. xx, p. 131, 1855), says, "the book is excellently planned, and is well adapted to its purpose, —that of a text-book for the Colleges and High Schools of the

Southern States." Professor Darby also published a Class-book of Chemistry. He was married August 20, 1833, to Miss Julia P. Sheldon, daughter of Calvin Sheldon, of Manchester, Vt. Professor Darby enjoyed the enviable reputation of a man of high character and pure life, zealously devoted to teaching in his chosen departments. B. S.

7. *Herbarium for sale.*—The herbarium of the late Arthur Schott is offered for sale, for the benefit of his family. It is said to contain 7,000 species, in good condition, and to be rich in plants of the U. S. and Mexican Boundary, of Mexico, and of Central America; a good many from Southern Germany and Hungary. Application to be made to H. Schott, Georgetown, D. C.

8. *Zoological Diagrams;* by LEUCKART and NITSCHE.*—Professors R. Leuckart and H. Nitsche have just issued the first number of an extended series of zoological diagrams for the use of universities and schools. They propose to issue from one hundred to one hundred and ten such diagrams, both plain and colored, to illustrate the structure and development of the principal forms of animal life. They intend to copy their illustrations mainly from the monographs of special investigators of acknowledged excellence, and to reproduce the figures of a sufficient size to be easily seen in a class-room of moderate dimensions. The diagrams are to be accompanied by an explanation of the figures, with German, French and English text. The authors intend to take special care not to follow any school of zoology and always to indicate in the text the sources from which their figures have been derived; they do not propose to follow a strictly systematic order in the issue of the parts, but the separate numbers will always contain figures from different types and groups of the animal kingdom. Professors Leuckart and Nitsche will indicate by their initials the plates for which each is personally responsible. The plates are issued at a very moderate price, at far less than an ordinary draughtsman can afford to make similar diagrams.

The three plates of the first number are devoted to Corals, Rhizopods and Isopods; the coloring of the various organs and of special parts is identical in the different figures, thus greatly facilitating the comparison of different animals.

It is a great pity that both the French and English text should be marred not only by serious misprints but also by the most extraordinary translations of the German explanation of the figures. The structure of some of the French and English sentences is truly marvellous, and we earnestly hope that the authors will employ a Frenchman and an Englishman to revise the text for the succeeding numbers. It would often puzzle a reader who does not know French and English as well as German, to make out the meaning of the text.

But these are minor defects, and if the work is carried out as it has been commenced, it cannot fail to be a most valuable guide to

* Zoologische Wandtafeln; v. Dr. R. Leuckart u. Dr. H. Nitsche. Erste Lieferung Tafel I–III. Cassel, 1877.

teachers of zoology, for they may rest assured that the distinguished editors will give them nothing which has not stood the test of time, and we most cordially recommend the series.

A. AG.

IV. Astronomy.

1. *The Sun's Distance.* (Abstract of the Report of the Astronomer-Royal on the Telescopic Observations of the recent Transit of Venus, from Nature of Nov. 1).—A most interesting state paper has just been issued; we refer to the Report by the Astronomer-Royal on the Telescopic Observations of the Transit of Venus of 1874, made by the Expeditions sent out by the British Government and the results deduced from them. The Astronomer-Royal suggests that another report may be called for when the photographs of the transit have been completely measured and worked out, if possible in combination with the results of similar observations made in the expeditions organized by other governments.

It will be seen from the present report that the plan of operations actually pursued has been very nearly that proposed by the Astronomer-Royal in his communication to the Royal Astronomical Society on December 11, 1868, when for the third time directing attention to the arrangements which it would be necessary to make for the efficient observation of the transits of 1874 and 1882. The method of absolute longitudes was to be applied for observations both of ingress and egress; it being therefore essential that the longitudes of the observing stations should be determined with precision; and the longitudes recommended to be fixed by Great Britain were Alexandria, stations in New Zealand and in the Sandwich Islands, Kerguelen's Land, and Mauritius or the two islands of Rodriguez and Bourbon.

The stations eventually selected for observatins by the British expedition were fixed upon "entirely by consideration of the influence which their positions would have in determining with accuracy the necessary alteration of parallax." They were: Egypt, the Sandwich Islands, the Island of Rodriguez, New Zealand, and Kerguelen's Land. It was intended to adopt in each of these districts one fundamental station, the longitude of which was to be independently determined, for conversion of local times into Greenwich times, and subordinate to this primary station, other stations were proposed to be selected at such distances that advantage might be taken of different states of weather that might possibly prevail.

In Egypt his Highness the Khedive rendered every possible assistance, tents being supplied with military guards for the protection of the observers and their instruments, and telegraph wires erected. The Astronomer-Royal acknowledges the obligations of the expedition to the liberality of the Eastern Telegraph Company, in affording the means of determining with extreme accuracy and great facility the longitude of the principal station Mokattam.

Greenwich was easily connected with Porth Curno, in Cornwall, whence there is an uninterrupted line to Alexandria, the longest submarine line in the world; Alexandria was connected with Mokattam by aid of the special line constructed by the Khedive from Cairo to the station. It is further stated that time-communication was also made from Mokattam through Cairo to Thebes, and to Suez by the ordinary telegraph, Thebes and Suez being the other Egyptian stations where the transit was observed.

In the Sandwich Islands much assistance was received from King Kalakaua and members of the reigning family. The principal station was at Honolulu, the longitude of which was determined partly by meridian-transits of the moon and partly by transits of the moon observed with the Altazimuth instrument. Waimea, in the island Kauai, where observers were also placed, was connected with Honolulu by means of chronometers carried in H.M.S. *Teredos*. At the Island of Rodriguez the longitudes were determined in the same manner as for the Sandwich Islands stations, for three positions, viz: Point Venus, the Hermitage, and Point Coton; and communication was further made with the Mauritius and with Lord Lindsay's expedition with the aid of H.M.S. *Shearwater*, the preliminary results being stated by Sir George Airy to agree closely with those given by the lunar observations. At Kerguelen's Land, again, the operations were similar; Supply Bay and Thumb Peak being the stations chosen.

In New Zealand unfavorable weather much interferred with the observations, and Sir George Airy had at first been led to suppose that all useful observation had been lost; it subsequently appeared, however, that this was not the case, one phase of the transit being well seen at Burnham, the longitude of which was fixed by meridian transits of the moon.

The report is divided into three sections or tables. In the first are given the descriptions of the various phenomena, in the words of the observers, with the Greenwich sidereal times of the different phases, obtained from accurate reduction of the observations for longitude here particularized; where such longitudes depend upon lunar observations the places of the *Nautical Almanac* were carefully corrected by observations on nearly the same days at Greenwich, Paris, Strasburg, and Königsberg. In studying these original descriptions, Sir George Airy was led to infer that it was "possible to fix upon three distinct phases for the *Ingress* and four for the *Egress*," though it might have been supposed that Egress and Ingress would exhibit the same number of distinct phases in inverse order; this was not the case in practice. The first phase, α, utilized in the calculations is the appearance of the planet just within the sun's disc, but the light between the two limbs being very obscure. After an interval of about twenty seconds "the light begins to clear, and the observers generally think that the contact is passed;" this is phase β. About twenty seconds later, the light which at phase β was not equal to that of the sun's limb, is free from all shadow, and the phase is called γ. Sir

George Airy finds that of these phases β is the most exact, observers, even in the presence of clouds of moderate density, agreeing within three or four seconds, though for other phases much greater discordances are exhibited. Similarly at the Egress, the first appearance of a fine line or faint shadow is called δ, this becoming definite, or a "brown haze" appearing, is called ε. When most observers record "contact," the shadow having reached a maximum intensity, the phase is called ζ, and in this phase there is an agreement amongst observers, much closer than in other phases at Egress. The "circular" contact at Egress is called η.

In the second section of the report, or Table II, these "adopted phases are massed for each district in which the parallax-factor is nearly identical," and several of the details of reduction are included. With the longitudes determined as above, the recorded time of the various phases of the transit were converted into Greenwich sidereal times. With the calculated apparent places of the sun and Venus in the *Nautical Almanac*, as deduced from Leverrier's Tables, an ephemeris was prepared exhibiting the predicted geocentric places for every tenth second of Greenwich sidereal time throughout the transit, and from these numbers the apparent positions of sun and planet at each station were computed. Calculations were further made, showing how the predicted places would be affected by alteration of the local longitude, by change in the tabular places of the sun and Venus, and by alteration of their tabular parallaxes; the first two alterations were not essential in these reductions, but the determination of alterations of the third class, as it is remarked, constituted "the special object of the expedition." The form of the reductions was "entirely determined by the consideration that such alterations must be made in the parallaxes as will render the observations of the same phenomena in different parts of the earth consistent with each other." In Table III. we have "the mean solar parallax deduced from every available combination." Thus Ingress accelerated at the Sandwich Islands is compared with Ingress retarded at Rodriguez and with Ingress retarded at Kerguelen's Land; Egress retarded at Mokattam and Suez with Egress retarded at Rodriguez, and likewise with Egress accelerated at the two stations in Kerguelen's; and again the retarded Egress at Thebes is compared with Egress retarded at Rodriguez and with Egress accelerated at Kerguelen's. The greatest separate value of the solar parallax resulting from these different comparisons is $8''{\cdot}933$ and the least $8''{\cdot}407$. Weights are given to the various determinations depending firstly, upon the number of observations and the magnitude of the parallax-factor; and secondly, upon the particular phase α, β, γ, δ, ε, and ζ being included. Thus it is found that all the combinations for *Ingress* give the mean solar parallax $8''{\cdot}739$, weight 10·46, and all the combinations for *Egress* give $8''{\cdot}847$, weight 2·53, whence the general result is $8''{\cdot}760$, from which Sir George Airy finds the mean distance of the sun equal

to 93,300,000 miles. The New Zealand observations were not included in these calculations; their mean result is 8″·764, almost identical with the above. It is remarked that many persons may perhaps consider that the more closely-agreeing phases β and ζ should be employed in deducing the value of the parallax to the exclusion of the others. If this be done we shall have from the *Ingress* 8″·748, and from the *Egress* 8″·905, or with their due weights a mean value 8″·773.

In this outline of the details contained in the Astronomer-Royal's first report upon the observations of the transit of Venus, and the conclusions to be drawn from them we have adhered closely to his own words. Pending the appearance of the deductions to be made from the complete measuring of the photographs, the results before us are perhaps to be regarded as provisional ones only, or we have not yet learned all that may be done from the work of the British expeditions, so laboriously organized by Sir George Airy. Many astronomers we can imagine will regard with some suspicion so small a parallax as 8″·76, which is a tenth of a second less than has been given by the most reliable previous investigations, upon different principles. In illustration we may quote the separate results from which Prof. Newcomb obtained his value of the parallax, now adopted in most of our ephemerides:—

From meridian observations of Mars, 1862	8″·855
From micrometric observations of Mars, 1862	8″·842
From parallactic inequality of the moon	8″·838
From the lunar equation of the earth	8″·809
From the transit of Venus, 1769 (Powalky's reduction)	8″·860
From Foucault's experiments on light	8″·860

To these may be added Leverrier's value subsequently deduced from the planetary theories, which is also 8″·86. Newcomb's mean figure, taking account of weights corresponding to the probable errors is 8″·848, which, with Capt. Clarke's measure of the earth's equator, implies that the mean distance of the sun is 92,393,000 miles. Sir George Airy's 8″·760 would similarly place the sun at a mean distance of 93,321,000 miles.

It is well known that some astronomers have not expected our knowledge of the sun's distance to be greatly improved from the observations of the transit of Venus, regarding such an opportunity as is presented by a close opposition of Mars as affording at least as favorable conditions, and the result of Mr. Gill's expedition to Ascension to utilize the late opposition will be on this account awaited with much interest. Nevertheless, whatever degree of opinion might be entertained by competent authorities, it appears to have been felt by those immediately responsible for action, in different civilized nations where science is encouraged, that so rare a phenomenon as a transit of Venus could not be allowed to pass without every exertion being made to utilize it, and this country may lay claim to an honorable share in the great scientific effort, thanks mainly to the long-continued and admirably-directed endeavors of the Astronomer-Royal to secure this result.

Several of the stations occupied during the transit of 1874 will be available for the transit of 1882, Kerguelen's Land in particular, where at Ingress the sun will be at an elevation of 12°, the factor of parallax being 0·98. In that year there will also be the advantage of observations along the whole Atlantic sea-board of the United States and Canada, where, as pointed out by the Astronomer-Royal in 1868, the lowest factor is 0·95, and the smallest altitude of the sun 12° for observing the retarded Ingress; and for observing the Egress as accelerated by parallax, the factors are about 0·85, the sun's elevation varying from 4° at Halifax, to 32° at New Orleans, or Jamaica. Australian and New Zealand stations are important for retarded Egress.

As is well known, the transit of Venus on December 6, 1882, will be partly visible in this country.

V. Miscellaneous Scientific Intelligence.

1. *Notes on the Rocky Mountains;* by Sir Joseph Hooker. (From Nature of Oct. 25.)—In company with Dr. Asa Gray, Professor of Botany of Harvard University, Cambridge, U. S., I availed myself of an oft-repeated invitation to us both from Dr. Hayden, the distinguished chief of the Topographical and Geological Survey of the United States Territories, to join the Survey in Colorado and Utah; this we did with the view of instituting a comparison between the floras of these central and elevated territories and those of other parts of the continent, and thus obtaining some insight into the origin and distribution of the North American flora. In order to comprehend the importance of Colorado and Utah as the basis for such investigations, I should state that they occupy a very central position in the continent, and include a section of the Rocky Mountains about 300 miles long and about as broad, namely, from N. lat. 37° to 41°, and from W. long. 105° to 112°.

The mountain region thus limited consists of extensive and often level-floored valleys, sometimes many miles broad, and elevated 4,000 to 5,000 feet above the sea, called "parks" in local topography, which are interposed between innumerable rocky mountain ridges of very various geological age and formation, which often reach 12,000 feet, and sometimes 14,000 feet elevation, the maximum being under 14,500.

Those of the so-called parks which are watered by rivers that flow to the east are continuous with the prairies that lie along the eastern flanks of the Rocky Mountains; those watered by rivers that flow to the west are continuous with the so-called desert or salt regions that lie along the western flanks of the range; but the divides between the head waters of the streams that flow either way are sometimes low, and the botanical features of the east and west may hence meet and mix in one park.

Such a section of the Rocky Mountains must hence contain representatives of three very distinct American floras, each charac-

teristic of immense areas of the continent. There are two temperate and two cold or mountain floras, viz: (1) a prairie flora, derived from the eastward; (2) a so-called desert and saline flora, derived from the west; (3) a sub-alpine; and (4) an alpine flora; the two latter of widely different origin, and in one sense proper to the Rocky Mountain ranges.

The principal American regions with which the comparison will have first to be instituted are four. Two of these are in a broad sense humid; one, that of the Atlantic coast, and which extends thence west to the Mississippi River, including the forested shores of that river's western affluents; the other that of the Pacific side, from the Sierra Nevada to the western ocean: and two inland, that of the northern part of the continent extending to the Polar regions, and that of the southern part extending through New Mexico to the Cordillera of Mexico proper.

The first and second (Atlantic plus Mississippi and the Pacific) regions are traversed by meridional chains of mountains approximately parallel to the Rocky Mountains; namely, on the Atlantic side by the various systems often included under the general term Appalachian, which extend from Maine to Georgia, and on the Pacific side by the Sierra Nevada, which bounds California on the east. The third and fourth of the regions present a continuation of the Rocky Mountains of Colorado and Utah, flanked for a certain distance by an eastern prairie flora, extending from the British possessions to Texas; and a western desert or saline flora, extending from the Snake River to Arizona and Mexico. Thus the Colorado and Utah floras might be expected to contain representatives of all the various vegetations of North America except the small tropical region of Florida, which is confined to the extreme southeast of the Continent.

The most singular botanical feature of North America is unquestionably the marked contrast between its two humid floras, namely, those of the Atlantic plus Mississippi, and the Pacific one; this has been ably illustrated and discussed by Dr. Gray in various communications to the American Academy of Sciences, and elsewhere, and he has further largely traced the peculiarities of each to their source, thus laying the foundations for all future researches into the botanical geography of North America; but the relations of the dry intermediate region either to these or to the floras of other countries had not been similarly treated, and this we hope that we have now materials for discussing.

Our course and direction in America was directly westward to Colorado, where we followed the eastern flanks of the Rocky Mountains for about 300 miles, that is from Denver in the north, to near the borders of New Mexico, ascending the highest northern and southern peaks, and visiting several intermediate parks and valleys, watered by tributaries of the Arkansas, Platte, Colorado, and Rio Grande. From Denver we proceeded north to Cheyenne in Wyoming, and thence westward by the Central Pacific Railway, across the range to Ogden, and the Great Salt Lake

in Utah, which lies on the base of the Wahsatch Mountains, themselves the western escarpment of the Rocky Mountains proper in that latitude. After ascending these we proceeded westward by rail through Utah, to Nevada, thus crossing the great dry region that intervenes between the Rocky Mountains and the Sierra Nevada, which is variously known as the Desert, Salt, or Sink region of North America, in accordance with the prevailing features of its several parts. It is elevated 3,850 to 6,000 feet, and traversed by numerous short meridional mountain-ridges, often reaching 8,000 feet, and rarely 10,000 feet elevation; unlike the Rocky Mountains or over the Sierra Nevada, these present no forest-clad slopes, and only the highest have a limited Alpine flora.

From Reno, at the western base of the Sierra Nevada, we proceeded south by Carson City, flanking the Sierra for some sixty miles to Silver Mountain, when we struck westward, ascending the Sierra, which was crossed obliquely into the Pacific slope. There we visited three groves of the "Big Trees" (*Sequoia gigantea*) at the headwaters of Stanislaus and Tuolomne Rivers, and the singular Yosemite Valley, whence we descended into the great valley of California, and made for San Francisco.

From the latter place we made excursions first to the old Spanish settlement of Monterey, which is classical ground for the botanist, as being the scene of Menzies' labors during the voyage of our countryman, Capt. Vancouver, in 1798 (whose surveys are held in the highest estimation by Professor Davidson and the officers of the Coast Survey of the United States), whom he accompanied as botanist. Then we went northward along the coast range to Russian River to visit the forests of Red-wood (*Sequoia sempervirens*), the only living congener of the Big Trees, and almost their rival in bulk and stature. Then to Sacramento, and up the valley of that name for 150 miles to Mount Shasta, a noble forest-clad volcanic cone about 14,400 feet in elevation. Returning thence to Sacramento we took the Union Pacific Railway eastward, and from the highest station visited Mount Stanford, on the crest of the Sierra Nevada, and Lake Tahoe, which occupies a basin in the mountains at about 7,000 feet elevation, and with which we finished our western journeyings.

In California the Coniferæ were a principal study, with a view of unraveling their tangled synonymy and tracing the variations and distribution of these ill-understood trees, which attain their maximum development in number of species and in stature on the Pacific slope of the American continent.

The net result of our joint investigation and of Dr. Gray's previous intimate knowledge of the elements of the American flora is, that the vegetation of the middle latitudes of the continent resolves itself into three principal meridional floras, incomparably more diverse than those presented by any similar meridians in the old world, being, in fact, as far as the trees, shrubs, and many genera of herbaceous plants are concerned, absolutely distinct. These are the two humid and the dry intermediate regions above indicated.

Each of these, again, is subdivisible into three, as follows:—

(1.) The Atlantic slope plus Mississippi region, subdivisible into (α) an Atlantic (β) a Mississippi valley, and (γ) an interposed mountain region with a temperate and sub-alpine flora.

(2.) The Pacific slope, subdivisible into (α) a very humid cool forest-clad coast range; (β) the great hot drier Californian valley formed by the San Joaquin River flowing to the north, and the Sacramento River flowing to the south, both into the Bay of San Francisco; and (γ) the Sierra Nevada flora, temperate, sub-alpine, and alpine.

(3.) The Rocky Mountain region (in its widest sense extending from the Mississippi beyond its forest region to the Sierra Nevada), subdivisible into (α) a prairie flora; (β) a desert or saline flora; (γ) a Rocky Mountain proper flora, temperate, sub-alpine, and alpine.

As above stated, the difference between the floras of the first and second of these regions, is specifically, and to a great extent generically absolute; not a pine or oak, maple, elm, plane, or birch of Eastern America extends to Western, and genera of thirty to fifty species are confined to each. The Rocky Mountain region, again, though abundantly distinct from both, has a few elements of the eastern region and still more of the western.

Many interesting facts connected with the origin and distribution of American plants and the introduction of various types into the three regions, presented themselves to our observation or our minds during our wanderings; many of these are suggestive of comparative study, with the admirable results of Heer's and Lesquereux's investigations into the pliocene and miocene plants of the north temperate and frigid zones, and which had already engaged Dr. Gray's attention, as may be found in his various publications. No less interesting are the traces of the influence of a glacial and a warmer period in directing the course of migration of Arctic forms southward, and Mexican forms northward in the continent, and of the effects of the great body of water that occupied the whole saline region during (as it would appear) a glacial period.

Lastly, curious information was obtained respecting the ages of not only the big trees of California, but of equally aged pines and junipers, which are proofs of that duration of existing conditions of climate for which evidence has hitherto been sought rather amongst fossil than amongst living organisms.

I need hardly add that the part I played in the above sketched journey was wholly subordinate to Dr. Gray's, who had previously visited both the Rocky Mountains and California, though not with the same object. But for his unflinching determination that nothing should escape my notice which his knowledge and observant powers could supply, and Dr. Hayden's active co-operation, my own labors would have been of little avail.

Moreover, throughout the expedition we experienced great hospitality, and enjoyed unusual facilities, not only from the staff of

the Geological Survey, but from the railway authorities, who franked us across the continent, and on all the branch lines which we traversed.

2. *The Earths of the Cerium Groups as found in the North Carolina Samarskite.*—In my original paper and subsequent note on this group of earths as separated by sulphate of potash from the mixed earths of North Carolina samarskite, I then stated that oxide of cerium was not to be ranked among them. I have continued the researches in this direction, and while they are far from being complete, it is pretty well determined that the bulk of the earth separated by the sulphate of potash is a *new earth*, if it be not *oxide of terbium*, an earth the existence of which is denied, and of the properties of which we have but a very imperfect knowledge. The other oxides of this group are thoria and oxide of didymium. I am still prosecuting my researches, and hope before long to give more positive results.—*J. Lawrence Smith's letter of Nov.* 14.

3. *Artificial Tremors through the Earth's Crust*, at the time of the Hallet's Point explosion in August and September, 1876; abstract of a paper by Henry L. Abbot, Major of Engineers, Bvt. Brig. General, read before the National Academy of Sciences at its recent meeting in New York.—Mr. Mallet's results, reported many years ago to the Royal Society, were:

Velocity in ft. per second in sand,		825 ft.
" " "	in discontinuous and much shattered granite,	1306 ft.
" " "	in more solid granite,	1665 ft.
" " "	in quarries at Holyhead (mean),	1320 ft.

The results, obtained by the officers of the United States Engineer School of Application at Willet's Point, for the rate through drift formation of Long Island, are the following:

Table I.

No. of observations.	Date.	Observer.	Cause of Shock.	Distance to station.	Type of seismometer.	Tremor of mercury.		Velocity of transmission.
						Arrived in	Lasted for	
				miles.		sec'ds.	sec'ds	ft. pr sec.
1	Aug. 18, '76.	Capt. Livermore	200 lbs. dynm.	5 ±	B	5 ±		5280 ±
2	Sept. 24, '76.	Lieut. Young	Hallet's Pt. ex.	5·134	A.	7 ±	63 ±	3873 ±
3	" " "	Lieut. Griffin	" " "	8·330	B.	5·3	72·3	8300
4	" " "	Lieut. Kingman	" " "	9·333	A.	10·9	23·5	4521
5	" " "	Lieut. Leach	" " "	12·769	B.	12·7	19·0	5309
6	Oct. 10, '76.	Lieut. Kingman	70 lbs. powder.	1·360	A.	5·8	inst't	1240
7	Sept. 6, '77.	Lieut. Kingman	400 lbs. dynm.	1·169	A.	1·8	7·8	3428
8	" " "	Lieut. Leach	" " "	1·169	B.	0·7	17·8	8814
9	Sept. 12, '77.	Lieut. Griffin	200 lbs. dynm.	1·340	A.	1·05	8·8	6730
10	" " "	Lieut. Leach	" " "	1·340	B.	0·81	17·1	8730
11	" " "	Lieut. Griffin	70 lbs. powder.	1·340	A.	1·27	4·8	5559
12	" " "	Lieut. Leach	" " "	1·340	B.	0·84	15·1	8415

In the case of No. 6 the charge was five feet below the surface. In those of Nos. 11 and 12 the charge was thirty feet below sur-

face, giving a much more violent shock than No. 6. Lieut. Leach reports, "I should say that it (the tremor) was at least two seconds in attaining a maximum." Hence, an instrument just capable of detecting it, would have registered only 2,489 feet.

TABLE II. (Analysis of above.)

No. of observations.	Seismometer A, (power 6).		No. of observations.	Seismometer B, (power 12).	
	Velocity of transmission.	Duration of tremor.		Velocity of transmission.	Duration of tremor.
	ft. per sec.	seconds		ft. per sec.	seconds
2	3873 ±		1	5280 ±	
4	4521		3	8300	
6	1240	instant	5	5309	
7	3428	7·8	8	8814	17·8
9	6730	8·8	10	8730	17·1
11	5559	4·8	12	8415	15·1
Mean.	4225			7475	

Conclusions. In such observations a high magnifying power of telescope is essential. The more violent the initial shock, the higher is the rate. This rate diminishes as the wave advances. For one mile, through drift formation, a severe shock gives a velocity of say 8,500 feet per second. The rate for the great Hallet's Point explosion was about 8,300 feet per second for the first eight miles, and about 5,300 feet per second for the first thirteen miles. These conclusions are supported by much additional evidence that cannot be stated in a tabular form.

4. *Recherches expérimentales faites avec les gaz produits par l'explosion de la dynamite sur divers caractères des météorites et des bolides qui les apportent*, par M. DAUBRÉE.—Professor Daubrée has carried on a series of experiments with dynamite similar to those he had previously performed with ordinary powder (Comptes Rendus, lxxxii, 949; lxxxiv, 413, 526), his design being to obtain an explanation for some of the most important characters of meteorites. Prisms of planed steel, each side having a surface of 85 mm., were subjected under different conditions, to the explosion of charges of two and of five kilograms of dynamite. The cartridge was in each case simply applied to one of the faces so as to act upon a single side only. The explosion took place at the bottom of a pit, some two meters in depth, so that all the fragments of the shattered steel could be recovered for examination. The immediate results of these experiments were as follows:—The mass acted upon was broken up into numerous polyhedral fragments, the planes of fracture being mostly perpendicular to the "*surface of action*" on which the force of the gas was felt. The surface directly exposed to the explosion showed numerous spheroidal depressions; these sometimes attained a diameter of 15 to 18 mm. and a depth of 4 to 5 mm. They were often grouped in lines, like the links of a chain, and in some cases were

bordered by an elevated ring. Outside of these distinct cavities the whole surface acted upon was fretted, or covered over with minute irregular depressions. Moreover the lateral faces showed fine, regular lines, parallel to the "surface of action," and produced by the violent crushing action of the exploded gas; and further, when these lateral faces were polished and etched with dilute acid, it was found that the parts close to the surface exposed to the gas had a peculiar tint which probably resulted from a sort of tempering which the surface had undergone from its rapid cooling. Again, of the fracture-surfaces, aside from those showing only a ragged break, some were polished and others finely striated, results which were due to the rubbing of the parts against each other at the instant of fracture. Finally, numerous cracks in the fragments of steel were compactly filled with the clay and sand from the walls of the pit, which had been forced into them. Characters analogous to those above enumerated as produced on the steel by the action of exploding dynamite, are commonly observed on meteorites; these are:—their fragmentary, polyhedral form; the pitted or "*piezoglyptic*" (graven under strain or pressure) character of their surfaces; the change of texture near the surface in the case of iron meteorites; the striated, fibrous surfaces in the interior of the mass, due to the rubbing of the parts against each other; the black veins ("lignes noires") resulting from a portion of the fused surface being pressed into cracks in the interior; and finally, the black marbled surface.

Professor Daubrée concludes that, as in the case of steel subjected to the action of dynamite, so also with the bolides and meteorites the effects observed are due mostly to the action of strongly compressed and hence highly heated gas. Although it is impossible to estimate, even approximately, the pressure exerted upon a bolide, from the time it enters the atmosphere until it explodes and scatters its fragments upon the earth, the conclusion is notwithstanding justified that it is comparable to the pressure exerted by the gas in the experiments with dynamite.

The writer would also ascribe the production of the large number of individual stones which have characterized some falls, as that of Pultusk in 1868, to the fracturing of an original mass by the compression of the air, and not by the unequal contraction due to a heated surface and a cold interior. He also calls attention to the fact that the "piezoglyptic" character of the surface is true of the whole meteorite, and not to one side only, and concludes from this that the moving mass must have had a motion of rotation, so that the different surfaces were in succession placed in front and subjected to the action of the compressed air.—*C. R.*, lxxxv. E. S. D.

5. *National Academy of Science.*—At a session held at Columbia College, N. Y., Oct. 23–25, 1877, the following papers were read:

STEPHEN ALEXANDER.—(1.) On the laws of extreme distances in the Solar system.—(2.) On the inclinations in a direction retrograde of the shadow of the planets.—(3.) On the luminous band which seems to encircle the moon during a partial solar eclipse.—(4.) Whence came the inner satellite of Mars?

A. M. MAYER.—On a new and simple method of determining the number of vibrations of sonorous bodies.

A. AGASSIZ.—On the development of Flounders.

T. GILL.—On the Morphology of the Antlers of the Cervidæ.

ELIAS LOOMIS.—Contributions to Meteorology (*eighth paper*).

HENRY L. ABBOT.—Velocity of transmission of shocks caused by the explosion of gunpowder and of nitroglycerine compounds, through the earth's crust.

JOSEPH HENRY.—On the abnormal phenomena of Sound, in relation to Fog Signals,—on behalf of the U. S. Light House Board.

O. N. ROOD.—(1.) On the photometric comparison of light of different colors.—(2.) On a construction for the study of the contrast of colors.

DR. M. IHLSENG.—On a method of studying of velocity of Sound in Wood. Presented by O. N. Rood.

J. S. NEWBERRY.—(1.) On some new fossil Fishes from Ohio and Indiana.—(2.) On the geological age of the Western Lignites.

J. LAWRENCE SMITH.—(1.) Notes on the analysis of Columbates.—(2.) Notes on the native iron and basalt of Greenland.—(3.) Exhibition of specimens showing the occurrence of sulphuret of chromium in meteoric iron.

JAMES HALL.—Note on the Hydraulic Limestone and associated strata at the Falls of the Ohio.

O. C. MARSH.—(1.) On some gigantic Dinosaurian Reptiles from the Wealden of the Rocky Mountains.—(2.) American Cretaceous Birds.

H. A. NEWTON.—On Comets. (Read by title.)

A. S. PACKARD, JR.—On the Air-sacs of Locusts.

JOSEPH LECONTE.—On the glycogenic functions of the Liver, and its relation to vital force and vital heat.

A. GUYOT.—Biographical memoir of Louis Agassiz. 1st part, relating to his life and work in Europe.

6. *Canada and New England Earthquake.*—A paper on this recent earthquake by Prof. Rockwood, now of Princeton, N. J., will appear in another number of this Journal.

7. *Thin Sections of Rocks, Minerals, etc.*, are made to order by A. A. Julien, School of Mines, Columbia College, New York, who also has made arrangements for sawing and polishing rocks, and polishing and etching meteorites. He has also collections of slides of various rocks on sale.

OBITUARY.

JAMES ORTON, Professor of Natural History in Vassar College, died in Bolivia about the 24th of September while crossing Lake Titicaca, and lies buried on a little island in the lake. He was born at Seneca Falls, N. Y., in the year 1830, and graduated at Williams College in 1853. Professor Orton was on his third tour to South America. In 1867–68, he took charge of an expedition to the Upper Amazons, under the auspices of the Smithsonian Expedition and along with a party from Williams College; and, in 1873, he made a second exploration of the Amazon, penetrating to Bolivia. About ten months since he left for his third exploring tour, with the design of tracing the waters of Eastern Bolivia to the Amazon. This Journal contains communications from Professor Orton, in volumes for the years 1868, 1869, on points in the Physical Geography of Quito and of the Andes and Amazons, and on the Geology of the Andes of Ecuador; and in 1870, appeared his work entitled "The Andes and the Amazon, or across the Continent of South America," giving a full account of his observations and discoveries.

APPENDIX.

ART. LII.—*A New Order of Extinct Reptilia (Stegosauria) from the Jurassic of the Rocky Mountains;* by Prof. O. C. MARSH.

THE Museum of Yale College has recently received the greater portion of the skeleton of a huge reptile, which proves to be one of the most remarkable animals yet discovered. It was found on the eastern flank of the Rocky Mountains, in beds which I have regarded as corresponding nearly to the Wealden of Europe, and which may be classed as upper Jurassic. The remains are well preserved, but are embedded in so hard a matrix that considerable time and labor will be required to prepare them for a full description. The characters already determined point to affinities with the Dinosaurs, Plesiosaurs, and more remotely with the Chelonians, and indicate a new order, which may be termed *Stegosauria*, from the typical genus here described.

Stegosaurus armatus, gen. et sp. nov.

In this specimen, some of the teeth preserved have compressed crowns, and are inserted in sockets Others are cylindrical, and were placed in rows, either in thin plates of imperfect bone or in cartilage. The latter are especially numerous, and may possibly prove to be dermal spines, having all the essential characters of teeth, as in some fishes. The vertebræ are biconcave, their neural arches being coosified with the centra, and the chevrons articulated. The limb bones indicate an aquatic life. The body was long, and protected by large bony dermal plates, somewhat like those of *Atlantochelys* (*Protostega*). These plates appear to have been in part supported by the elongated neural spines of the vertebræ.

The length of one of the compressed teeth of this species is 112 mm., and the greatest diameter of the crown 24 mm. One of the cylindrical teeth is 75 mm. in length, and 7·5 in diameter. Seven of these teeth in position occupy a space of 63 mm. A trunk vertebra measures 450 mm. from base of centrum to top of neural spine, and 170 mm. to the floor of the neural canal. The extent of seven posterior caudal vertebræ is 660 mm. One of the large dermal plates was over three feet (one meter) in length.

The present species was probably thirty feet long, and moved mainly by swimming. For its discovery science is

indebted to Prof. A. Lakes and Engineer H. C. Beckwith of the U. S. Navy, who found the first remains in Colorado near the locality of the gigantic *Atlantosaurus montanus*, and in essentially the same horizon.

Yale College, New Haven, Nov. 15th, 1877.

ART. LIII.—*Notice of New Dinosaurian Reptiles from the Jurassic formation;* by Professor O. C. MARSH.

THE gigantic Dinosaur, *Atlantosaurus montanus*, described by the writer in the July number of this Journal,* proves to belong to a lower horizon than at first supposed, and is really from the upper Jurassic. Additional remains of the type specimen, moreover, throw considerable light on the structure of this largest of land animals, and indicate that it is the representative of a distinct family, which may be called *Atlantosauridæ*.

In the type genus, *Atlantosaurus*, one of the most important characters is the pneumaticity of the vertebræ, as mentioned in the original description. Another noteworthy feature is the absence on the femur of a third trochanter. The shaft of the bone is somewhat thickened at the point where this process should be, but the trochanter is wanting. The size of the original specimen of *A. montanus* may be estimated from the femur, which was about seven feet in length. If the animal had the proportions of a Crocodile, it was at least eighty feet long.

Apatosaurus ajax, gen. et sp. nov.†

Another gigantic Dinosaur, allied to the above, and of scarcely less interest, is represented in the Yale Museum by a nearly complete skeleton in excellent preservation. It is from the Jurassic beds in the Eastern foot hills of the Rocky Mountains, but from a somewhat lower horizon than the type of *Atlantosaurus*.

The cervical vertebræ are strongly opisthocœlous, and are rendered comparatively light by large pneumatic cavities in the centra. The anterior dorsals have similar characters. The posterior lumbars have the articular faces very nearly flat, and transverse. The sacral vertebræ are more solid, and have their transverse processes nearer the middle of the centra than in *Atlantosaurus*. The anterior caudals are biconcave, and their

* Vol. xiv, p. 87, 1877. The name *Titanosaurus* was first given, but, being preoccupied, may be replaced by *Atlantosaurus*.

† The principal characters of this genus and its nearest allies were given by the writer in a paper before the National Academy of Science, at the meeting in New York, October 25th, 1877.

interior structure is cancellous. The chevron bones differ from those of most known Dinosaurs in having the superior articular ends of the rami not united, but separated from each other, as in the Mosasauria with free hæmapophyses.

Some of the dimensions of this skeleton are as follows:

Length of centrum of anterior dorsal vertebra	220·mm
Transverse diameter of anterior face	310·
Vertical diameter	200·
Amount of convexity	90·
Length of centrum of lumbar vertebra	240·
Transverse diameter of anterior face	410·
Vertical diameter	270·
Length of median sacral vertebra	250·
Expanse of its transverse processes	760·
Length of centrum of median caudal	190·
Length of posterior caudal	185·

This animal must have been between fifty and sixty feet in length, and more than thirty in height when erect.

Apatosaurus grandis, sp. nov.

Another huge Dinosaur, apparently of the same genus, but of smaller size, is represented in the Yale Museum by the more important parts of a skeleton, in remarkable preservation. In this specimen the cervical vertebræ have the walls of the centra very thin. The caudals preserved are elongated and slender, indicating a long tail. The femur is comparatively short, and without a third trochanter. The great trochanter is much lower than the head of the femur, and continuous with it. The metapodial bones indicate a foot of medium length.

The following measurements indicate the size of the reptile:

Length of femur	1050· mm.
Transverse diameter of proximal end	340·
Transverse diameter of distal end	290·
Length of posterior caudal vertebra	145·
Vertical diameter of anterior articular face	110·
Transverse diameter	115·

The known remains of this species are from the same geological horizon as those above described. They indicate an animal at least thirty feet in length.

Allosaurus fragilis, gen. et sp. nov.

This genus may be distinguished from any known Dinosaurs by the vertebræ, which are peculiarly modified to ensure lightness. Although apparently not pneumatic, they have the weight of the centra greatly reduced by deep excavations in the sides. Some of them have the centra hour-glass in form,

the middle part being so diminished as to greatly reduce the strength. The vertebræ preserved are biconcave, with shallow cavities. The feet bones referred to this species are very slender. A lumbar vertebra has its centrum 105 mm. in length, and 89 in least transverse diameter. An anterior caudal, 35 mm. long, has its centrum so much constricted that its least transverse diameter is 38 mm., while its anterior face is 90 mm. in transverse diameter.

The animal indicated by the remains preserved was from fifteen to twenty feet in length. All the known specimens are from the upper Jurassic of Colorado.

Nanosaurus rex, sp. nov.

A diminutive Dinosaur, about as large as a fox, is indicated by some remains in good preservation, the most characteristic of which is a nearly perfect femur. In this bone, the great trochanter is prominent, and the third trochanter especially so. There is a well developed fibular ridge, directed outward and backward. The cavity in this bone is unusually large, and the walls are smooth. This femur agrees so nearly with that of the type of *Nanosaurus*, that the present species may be provisionally referred to that genns.

The dimensions of this bone are as follows:

Length of femur	100·	mm
Distance from head to middle of third trochanter	30·	
Transverse diameter of distal end	21·	
Greatest antero-posterior diameter	18·	
Least transverse diameter of shaft	11·	
Diameter across third trochanter	15·	

The known remains of this reptile are from the upper Jurassic of Colorado.

The specimens described in the present articles are deposited in the Peabody Museum of Yale College. They are all from essentially the same geological horizon, which I find to be upper Jurassic. The deposits which contained them may be called the Atlantosaurus beds, from their most characteristic fossils, the huge Dinosaurs of that genus.

Yale College, New Haven, November, 1877.

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